Greenhouse Construction and Heating

GREENHOUSE CONSTRUCTION

AND

HEATING.

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Heating:

CONTAINING

FULL DESCRIPTIONS OF THE VARIOUS KINDS OF GREENHOUSES, STOVE HOUSES, FORCING HOUSES, PITS AND FRAMES,

WITH DIRECTIONS FOR THEIR CONSTRUCTION,

AND ALSO

DESCRIPTIONS OF THE DIFFERENT TYPES OF BOILERS, PIPES, AND HEATING APPARATUS GENERALLY, WITH INSTRUCTIONS FOR FIXING THE SAME.

By B. C. RAVENSCROFT

(Author of "Tomato Culture for Amateurs," "Begonia Culture," "Carnation Culture," "Town Gardening," &c.).

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PREFACE.

I was induced to undertake the present work chiefly because there appeared to be no really practical, exhaustive, or modern guide to the construction and heating of glass structures—in fact there is, as far as I am aware, no work worth the name of any kind upon the subject. A somewhat voluminous treatise upon heating by means of hot water must be excepted, however, but if not exactly obsolete this is now decidedly out of date, and scarcely practical enough for the modern horticultural builder, besides which, some of the tables it contains are scarcely correct, or at least somewhat misleading.

In view of the enormous increase in indoor horticulture, or "market-gardening under glass," that has taken place during the last decade or two in this country, the absence of some such work is a matter for surprise, but since the want existed, and no more gifted hand essayed the task, I have done the best I could myself. I have endeavoured to treat the subject, as far as possible, from the point of view of a *grower* as well as of a *builder*, and I venture to hope that over a quarter of a century of practical experience and careful study of plant-growing and plant-houses has enabled me to point out the kind of structure most suitable for the various descriptions of plants, and for different purposes.

Whatever its faults, I can claim for the present work at least a thoroughly practical character. Most of the arrangements described I have, myself, carefully tried and tested, in many cases several times, and in all conclusions arrived at as to the respective value of different systems, I have been guided by actual and careful trial only.

In conclusion, I trust that if not of any great value to the professional builder, the work now put forth will, at least, prove of assistance to the immense army of amateurs whose desires in this direction greatly exceed their knowledge of the subject, and who wish to make the sum they have to lay out go as far as it possibly can.

B. C. RAVENSCROFT.

LAXEY, I.O.M.,
30th March, 1901.

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Greenhouse Construction and Heating.

CHAPTER I.

INTRODUCTION.

In these days of cheap glass, timber, and ironwork, a greenhouse of some kind, large or small, is within the reach of almost everyone, instead of, as of yore, a luxury attainable only by the rich. And a green—or plant—house, if only of small dimensions, undoubtedly forms a very valuable and useful adjunct to any garden, while even *per se* it affords constant interest and amusement at all seasons of the year. Even in wet or very cold weather, when out-door work is almost if not quite out of the question, there is always something to be done, as well as to be seen, in the greenhouse; and even such light, yet necessary, operations as watering and training the plants, picking off dead leaves, sowing seeds and inserting cuttings, afford at once occupation and interest, while enabling the lungs to absorb freely the life-giving oxygen newly exhaled by the plants themselves.

A well-kept greenhouse or conservatory, heated to a moderate and pleasant degree, also affords a delightful winter resort, and enables fresh air and gentle exercise to be taken, even by invalids and delicate persons, who would otherwise be unable to pass the house-doors in severe weather. There is nothing more truly healthful than the smell of the fresh earth, the perfume of flowers, and the exhalations of active vegetation, while the moderately-heated conservatory or plant-house enables us to enjoy the climate of Italy or the South of France only just outside our own doors! Constantly working in high temperatures is doubtless enervating in some degree, if not really injurious; but these are only necessary in the case of a comparatively few subjects, or for certain purposes, and a pleasant and moderate temperature of about 60 degs. Fahr. is quite sufficient for the great majority of flowering and foliage plants, fruits, etc.; at any rate during the seasons of winter and spring.

Again, how pleasant it is to be able to cut a handful of fresh and fragrant blossoms, a bunch or two of grapes, a few tomatoes, or the like, direct from the plants in one's own greenhouse! Such truly "home-grown" produce is *really* superior, as a rule, to anything of the kind bought in a shop, being, for one thing so much fresher, while quality and flavour may and should be studied by the private or amateur gardener to a much greater extent than is possible by the trade or market grower, whose chief aim is *quantity*, almost irrespective of any other consideration, mere appearance, however, excepted.

It has been said, and with a good deal of truth, that a man without a hobby is but a poor kind of creature; and there can be no doubt that a hobby, if a reasonable one, and not "ridden to death," is an excellent thing, both to the otherwise busy or idle man or woman either. Now, there is no hobby at once so healthful, innocent, and absorbing as gardening, and no branch of the art more interesting or generally beneficial than the culture of indoor flowers or fruits.

I cannot, however, advise my readers to attempt "growing for profit"; in fact, I must strongly recommend them, with scarcely an exception, to avoid anything of the kind, which in these days of severe competition, over-production and low prices, is too frequently a mere *ignis fatuus*. On a small scale, and in inexperienced hands, the expenses of "growing for market" are almost certain to exceed the returns, and the "profits" are consequently invisible. I do not mean to say that it is actually impossible to make anything in this way, even now; but the subject, or subjects, chosen must be popular ones, for which there is a large demand at fair to good, or, at any rate, remunerative prices; and if the adventurer, or adventuress, has some knowledge of the proper methods of culture, with sufficient capital to do the thing properly, and the undertaking is conducted in a methodical, persevering, and business-like manner, a reasonable degree of success may be experienced. But it must be understood that all such undertakings involve a large amount of hard work, and, still more, perseverance; while, without the means of tiding over a possible bad season or two, it had better not be attempted at all. In the great majority of cases it is far wiser for the inexperienced amateur to "grow" for interest and pleasure only, and to cultivate an assortment of any kind of plant for which he may have a fancy, or for the cultivation of which the soil, position, and other conditions may be favourable, to the best of his power.

In large and smoky towns, plants growing in a greenhouse are protected, to a great extent, by the glass roof, from the constantly falling particles of soot, dust, etc., that would otherwise be deposited on them, and are consequently both cleaner and healthier than those exposed to the open air.

Greenhouses are generally supposed to be very costly structures, and so they frequently are, though a great deal depends upon the way in which one goes to work. Elaborate constructions, in which heavy or fancifully wrought wood or iron work, coloured glass, powerful and intricate heating apparatus, and everything of the very best materials and workmanship are employed, are naturally and unavoidably expensive. So also are too frequently those erected by a professional horticultural builder, especially where a fixed or contract price is not agreed upon previously. For, although these men know exactly the right way to go to work (or ought to do so), it should be remembered that they have to employ skilled and reliable workmen, who have to be well paid, and to find travelling and other expenses as well, while lastly they must have a good margin of profit themselves, or they could not live. In fact, it is not so much the actual *materials* that cost the money so much as the *labour*, which is always a very heavy item, particularly when that of a skilled description has to be employed.

On the other side, a handy man, who can use the ordinary carpenter's tools, and do most of the wood-work, as well as the painting, glazing and fitting, himself, with perhaps the assistance of a lad, or ordinary labourer only, can put up a very creditable and useful structure for about half the amount it would cost to have the same thing erected in the usual way. Brickwork is certainly rather expensive, and it is not everyone who is able to undertake this himself, or would care to do so, but a very useful house for most ordinary purposes can be constructed with little or no brickwork, and even if this is necessary a decent bricklayer can usually be found who will run up a couple of low side-walls, or the like, for a very moderate sum.

Almost incredible as it may appear to many, it is, however, quite possible, with timber, glass, etc., at their present prices, for a man of the class just referred to to construct a good, useful, span-roofed or lean-to glass-house from 10ft. to 15ft. in width, and of proportionate height, properly fitted with ventilators, etc., complete, for the small sum of ten shillings (or even less) per foot run, inclusive, and also to heat the same in an efficient manner for another five or six shillings per lineal foot. This is, of course, provided that only a small or moderate amount of cheap, unskilled labour only is employed, and that the materials are obtained at the lowest, or maker's prices. Good sashbar stuff (rafters) already worked, and prepared from 3in. by $1\frac{1}{2}$in. quartering, can be had at almost any respectable timber yard for six or seven shillings per 100ft. (run), and the "plates," ridge, purlines, etc., at proportionately low rates. Several well-known firms also now make a speciality of the materials (timber, etc., only) for a greenhouse of 100ft. long by 10ft. or 12ft. in width, all ready for cutting up and fitting, with door, ventilators, etc., for the small sum of £9 or £10, and other sizes in proportion. How to construct one, or more, of such thoroughly efficient yet inexpensive houses is what I propose to show my readers in the course of the present work.

The cheap ready-made greenhouses now so largely advertised and sold are in many cases very useful and even creditable little structures, and thousands of them are in use all over the country. I have frequently seen excellent results obtained with houses of this class, and often under the most unlikely conditions, but this is only to be accomplished by means of constant attention and care, which to a great extent compensate for lack of skill, or of superior appliances. But as a rule, these little structures are better adapted for use as *conservatories*—that is to say, places for preserving plants in—than for actual *growing* purposes, and their form, size, and general construction are frequently far from being the most suitable for the particular purpose or position intended. As I have already stated, anyone with a knack of carpentering, etc., and not afraid of a little hard work, can put up a larger and altogether better and more useful structure in this way, by performing the greater part of the labour himself, for a much less cost than a ready-made house would run to, and in these days, when most of us want to make our money go as far as possible, this is an important consideration.

But supposing a greenhouse of some kind, larger or smaller, to have been erected, or purchased, it will be of comparatively little use for the culture of tender plants (except, of course, during the summer months, from May till September) unless heated in some way. And to accomplish this also in an economical and yet thoroughly satisfactory manner is often nearly, if not quite, as costly, and an even more troublesome matter, than the construction of the house itself. Not that a cold or unheated structure is by any means without its uses, and, indeed, for certain purposes, such as preserving calceolarias, pentstemons, and other nearly but not perfectly hardy plants during the winter, protecting the blossoms of Christmas roses, violets, laurustinus, the early-flowering irises, hardy cyclamens, etc. ; as well as for wintering carnations, auriculas, roses and others in pots, an unheated greenhouse is a really valuable addition to a garden. It is also by no means necessary for what are termed orchard-houses to be artificially heated, and some vines may also be grown fairly well in an unheated structure, if situated in a warm and sunny position, though a little artificial heat is generally a very great advantage in the culture of grapes of all kinds. But in order to obtain flowers or fruit of most descriptions in the winter season, to raise bedding or other plants of a tender nature in good time, from seed or otherwise, not to mention anything of the nature of forcing, some amount of artificial heat is absolutely necessary.

Further, the best and most satisfactory results, from a cultural point of view, are obtainable only by having every structure specially constructed for and adapted to the particular purpose for which it is intended, and the method of heating ought also to be suited to the probable requirements. Houses for the growth of cucumbers, for instance, should be of totally different construction to those in which tomatoes, pelargoniums, or the like are to be cultivated. In fact, almost every class of plant in cultivation is found to succeed best when grown in houses constructed specially with a view to meet the peculiar nature and requirements of each as nearly as possible. Orchids, in particular, usually thrive best in houses designed specially for them, and the requirements of the different classes of this wonderful order of plants, as to heat, moisture, ventilation, etc., vary greatly.

And yet the best plants are frequently grown in cheaply constructed houses; and most growers for market, especially those whose chief aim is profit, make use of such as are built in the simplest manner and at the least possible cost. The late Mr. P. Ladds, of Bexley, one of the most successful of all the great London market growers of greenhouse plants and flowers, began his career with houses of this description, most of those first erected at his old nursery at Bexley Heath being of the roughest possible character, the sashbars neither planed nor painted on their undersides, but prepared from the rough material, and the houses heated only by means of a single 4in. flow and return pipe running along the central pathway. Nevertheless, it was with such appliances as these that this well-known grower made the greater part of his "pile," and though the houses in the huge nursery at Swanley, which Mr. Ladds established subsequently, are of more pretentious construction, neither are these, by any means, elaborate or costly erections. Another market grower, who realised a large fortune a few years since, employed houses built in the cheapest possible manner, the sides being formed of sheets of galvanized iron only; and in Mr. Beckwith's huge nurseries at Tottenham and Hoddesdon most of the houses were built with concrete walls, rafters or "bars" of T iron (bent to the proper angles and bedded in the concrete at each end), and glass, the squares being for the most part 24in. in width.

As the poet Cowper says in one of his charming metrical essays, "Who loves a garden loves a greenhouse too"; but the mere possession of a greenhouse, however excellent in construction, will not alone enable one to enjoy an abundance of fragrant blossoms and fine fruit, the great secret of success in all indoor horticulture being constant and untiring attention and care, with some amount of experience and judgment. Yet the possession of a moderate-sized house or two not only greatly extends the season of enjoyment in the garden, but also enables the out-door department to be stocked in a much more varied and pleasing manner.

CHAPTER II.

DIFFERENT FORMS OF GREENHOUSES, ETC.

THERE are three chief or principal forms of greenhouses, viz., the span-roofed (Fig. 1), the lean-to (Fig. 2), and the

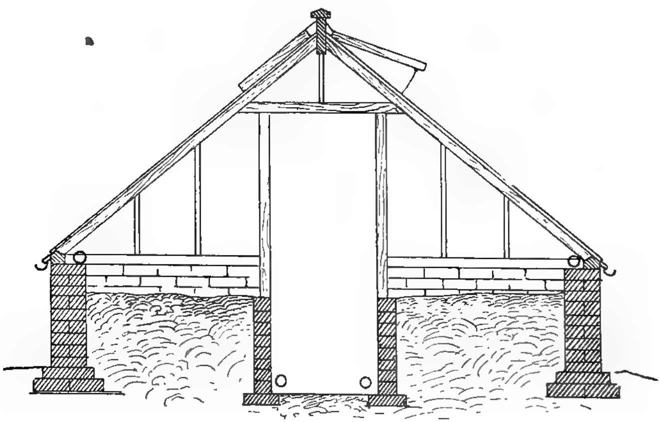


FIG. 1.

three-quarter span, or hip-roofed (Fig. 3). Of these the first is the most suitable for all ordinary purposes and in the majority of cases, as the plants within receive more light, and this reaches them more equally on all sides than in either of the other forms, while such houses may be erected in any open position away from an existing wall or building. For both the other forms a back wall of some kind is necessary. Where this is under 8ft. or 9ft. in height the three-quarter span form is most suitable,

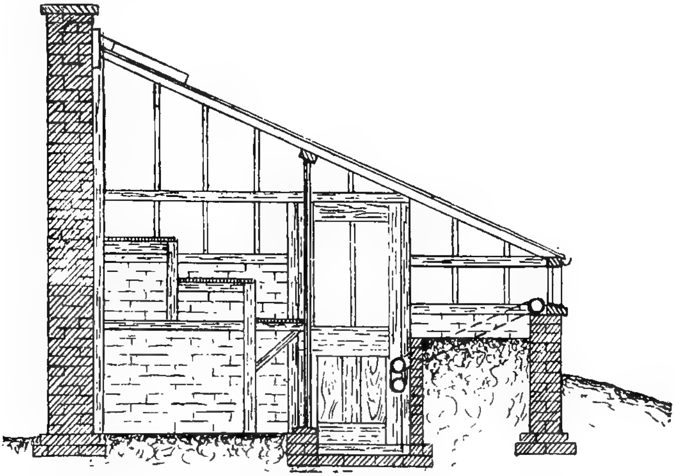


FIG. 2.

but if the wall is much higher than this a lean-to structure had better be erected. Upon the dimensions and proportions of the house, however, the proper height of the back wall depends, of course, in all cases. Where there is already an existing back wall, equally suitable for either form of structure, the three-quarter span should, as a rule, receive the preference, as even when the front has to be heavily shaded the plants still receive the benefit of a good deal of light through the glass on the north side.

A lean-to or three-quarter span-roofed house built against a wall with a south, south-west, or even south-east aspect is usually very warm—appreciably more so than

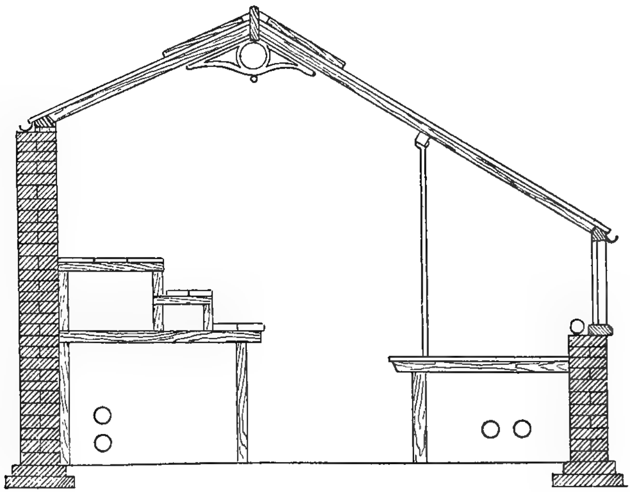


FIG. 3.

an isolated span-roofed structure would be under similar circumstances — receiving every ray of sun there is (especially during the winter season), while the solid wall at the back acts powerfully as a screen from cold north or easterly winds. Such houses are consequently well adapted for forcing purposes and the production of early crops of various kinds, but as the season advances, span-roofed structures erected in open positions frequently afford the best results. Houses of either of these forms (lean-to and three-quarter span) may also be erected against east, west, or even north walls, but in the latter position they are only of use for the culture of ferns, palms, lapagerias, and other shade-loving subjects, owing to the lack of sunlight, or in the height of summer to preserve or retard flowering plants of various kinds.

To return to the span-roofed form. Houses of this class may run, or trend, either north and south, or in an easterly and westerly direction. For most purposes the former is found to be the best position, as the occupants then receive the full benefit of the sun in the mornings and evenings, while during the middle of the day, when the sun's rays are often injuriously strong (in summer), they are "broken" to a considerable extent by the sash-bars, etc., the sun being then "end on," as it were. In such structures the plants also receive the light more fully and equally on both sides; but on the other hand, in winter, when every ray is precious, they do not get so much sun as those standing in houses running the other way. Where plants are to be forced early in the season, or grown for winter flowering, one or more span-roofed houses running east and west will be found very suitable, and with the addition of moveable blinds on the south side, similar structures will do capitally for gloxinias, begonias, orchids, and other delicate plants that require to be shaded from strong sun in summer. North and south houses do not require blinds, a dash of whitewash over the glass in very bright summer weather being usually quite sufficient.

Beyond the three principal forms, there are a considerable number of others, chiefly more or less complicated, but those already mentioned are decidedly the most useful for all ordinary cultural purposes, and with scarcely an exception, are employed by the large trade and market growers of flowers, fruit, etc. Conservatories, properly so called (as distinguished from houses for "growing" purposes), may be, and frequently are, constructed in many and various ways and forms, such as square, sexagonal, octagonal, and even circular, with fantastically gabled "ridge and furrow," curvilinear, and other forms of roof, and also with lead and other kinds of ornamental glazing, coloured glass, and so forth, according to the fancy of the proprietor or architect, or to harmonise with the style of the house or mansion to which they are attached. Such erections, though frequently highly ornamental (and not seldom simply hideous) are usually quite useless for "growing" purposes, and in many cases if plants of certain kinds are kept in them for any length of time they suffer severely. Structures of this class are consequently briefly dealt with in a later chapter.

In large market and other nurseries a number of span-roofed houses of the same size and character are frequently built side by side, so as to form a block. If, in such cases, side-ventilation is required, a space must be left between each pair (in order to allow of the ventilators or sashes being opened), with separate walls to each structure (see Fig. 4). But where "side-air" is unnecessary, as in the case of houses intended for cucumber growing, etc., they may be built contiguously, the same wall being made to serve for a side of each, and a gutter being arranged on the top to carry off the water from the roofs on each side (see Fig. 5). Another plan sometimes adopted in constructing a block of contiguous houses intended for one class of plant only is to carry the eaves of both houses on an extra stout and heavy, as well as wide "plate" (see pp. 51 and 72), this being supported merely by means of brick piers built a few feet apart, a gutter being fixed on top of the plate, as before.

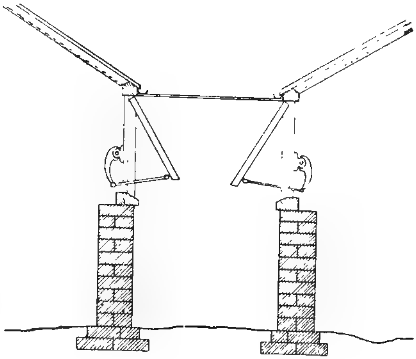


FIG. 4.

Of course, this leaves the houses open to each other beneath the eaves, and the plan is only permissible where the same temperature is to be maintained in all the houses thus connected. Where several roofs are thus constructed contiguously, the gutters between should be made wide enough for a man to walk along in them easily, for the purpose of repairing the glass, painting, etc.

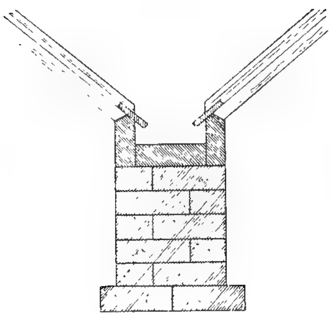
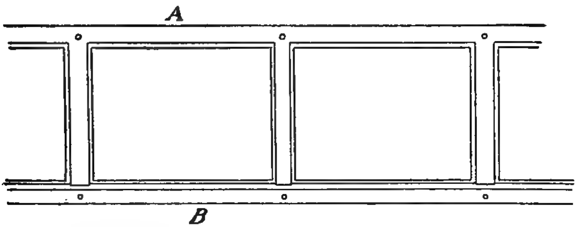


FIG. 5.

Greenhouses are in most cases built on low walls of brick, stone, or concrete (though in some instances boards



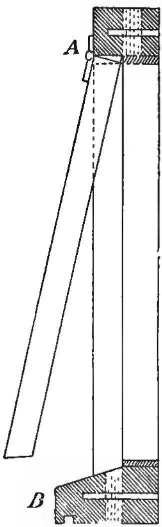


FIG. 6.

are used for the sides), the glass of which the roof consists being carried in suitable wooden rafters, which are properly grooved or "rebated" for the purpose. The timbers which are laid on the top of the walls, and to which the lower ends of the rafters are nailed, are termed "wall-plates," and along the apex of the roof, where the two sets of rafters meet (in a span-roofed or three-quarter span house) runs a piece of timber called the ridge plank. This serves at once to keep the rafters at their proper distances apart and to hang the ventilators to.

Where any part of the sides of the house is composed of glass this is usually fitted in sashes or framed lights, and in this case *two* "plates" are necessary—an upper one (A) to carry the ends of the rafters, and the usual lower or wall-plate (B), see Fig. 6.

The old-fashioned system of constructing the roofs of greenhouses was with what are termed "principal" rafters of stout quartering, placed 3ft., 4ft., or 5ft. apart, the intervening spaces being filled in with one or more (according to the length of the rafters) sashes, constructed in much the same manner as an ordinary frame-light. This method is still employed to a considerable extent in the construction of conservatories and "show-houses"; but, though affording a very substantial structure, this has a somewhat heavy appearance, and does not admit enough light for the ordinary market grower's requirements. A maximum of light being necessary to the production of the dwarf and stocky growth that is so much desired, especially in the culture of plants in pots, &c., nurserymen prefer to erect houses with roofs of the lightest possible construction, consisting of wide squares of glass, supported by few and narrow bars (rafters), and offering the least possible obstruction to light and sun. Principal rafters are consequently dispensed with altogether in the majority of such structures, the rafters consisting of plain sash-bar stuff, usually 3in. by 1½in., or not more than 3in. by 2in., in section, with squares of glass, 16in., 18in., or in some cases 21in. or even 24in. wide between. If the rafters are too long to carry the great weight of glass safely, they are supported about the middle by means of a purline and standards, as shown in Fig. 29 on p. 50, and Fig. 42, p. 61.

When "principal" rafters are employed it is not absolutely necessary to used framed lights or sashes between them; but the spaces may be filled with small sash-bar stuff (2½in. by 1¼in., or 2in. by 1in. in section), placed 8in.

to 12in. apart, and supported in the middle, in the case of long roofs, by one or more cross-bars of angle or other iron. These last are secured to the principals at each end, and drilled and screwed to each bar, and may be fixed in one, two, or even three places, according to the length of the rafters. If sashes are used, some of the upper ones—usually those in each alternate "bay"—are fitted so as to slide, like a window-sash, and are pulled up and down by means of cords and pulleys, and thus used as ventilators (see p. 35).

When preparing to erect a greenhouse of any magnitude, the first thing, after deciding upon its dimensions, etc., is to make a set of drawings to scale, including a ground plan, elevation and cross section. If this is carefully done, going into the details as far as possible, it will be found of great assistance in working, as the pitch and many other important points, as well as the size and position of the doors, ventilators, etc., can be obtained from such plans almost at a glance.

In designing a horticultural building of any kind, the chief point to be considered is the purpose for which it is intended. As already stated, one class of plants is found to succeed best in a certain type of house, and others in another, so that where, as usual, the highest degree of excellence is desired, it is most important that each and every structure be specially designed and adapted for the particular subject or purpose in view. Certain plants, as for instance the tomato, rose, camellia, and others, always thrive best in very light and airy houses, preferably of considerable dimensions and abundantly ventilated. Cucumbers, on the other hand, require very little ventilation, and usually succeed best in low and very closely constructed or "tight" structures of comparatively small cubic contents, fitted with plenty of piping, so that a high temperature may be easily maintained. A similar class of house would be suitable for the culture of exotic ferns, small palms, and stove plants generally, but for larger palms, bananas, and other tropical subjects of considerable growth, height must be afforded as well as a brisk temperature. Vines should, of course,

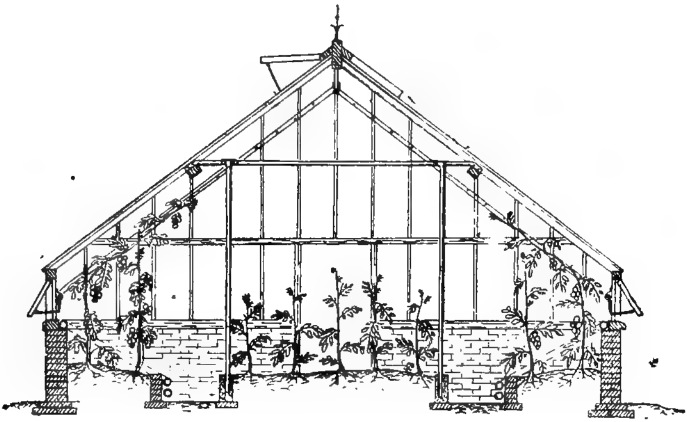


FIG 7.

be allowed fairly lofty or roomy structures, and for peaches, etc., abundance of both light and air, with a fair allowance of space are necessary. Lastly, ordinary "geraniums," (pelargoniums) as well as the majority of the usual "cool" greenhouse and bedding plants, etc., require plenty of air and light, and to be kept near the glass, so as to ensure a dwarf and bushy habit of growth, so that for all such low, yet light and well-ventilated, houses are desirable, and what are termed "hard-wooded" plants (including the heaths or ericas, with epacris, azaleas, boronias, and others) in particular must receive abundance of light and pure air at all times.

As putting the matter in a still more plain and concise form, the following may be useful :—

Tomatoes succeed best in wide and lofty houses, very light, and abundantly ventilated ; much artificial heat being unnecessary, except for early crops. Structures 20ft. to

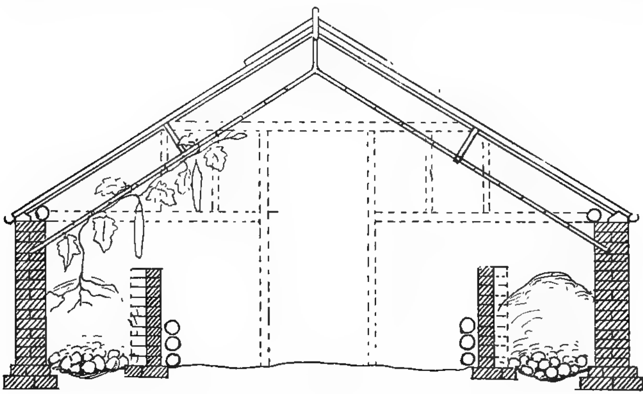


FIG. 8.

30ft. in width and proportionately lofty, with a moderately steep pitch of roof, are now usually employed for this crop (see Fig. 7).

For **Cucumbers**, low, close houses, with moderately flat roofs, are best. They must be fitted with brick beds on each side (if span-roofed), with hot water pipes running along the bottom of each, as shown in Fig. 8. Cucumber-houses always used to be constructed 12ft. in width, but

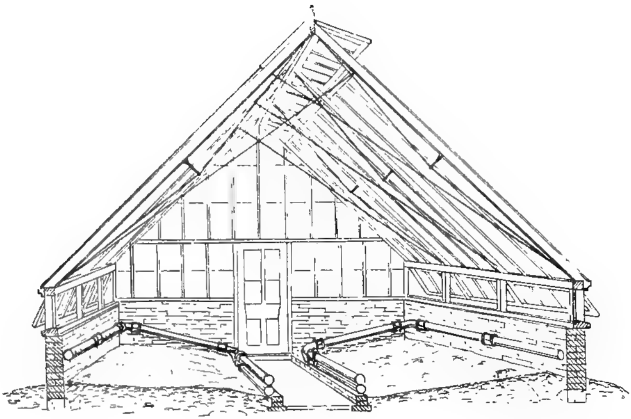


FIG. 9.

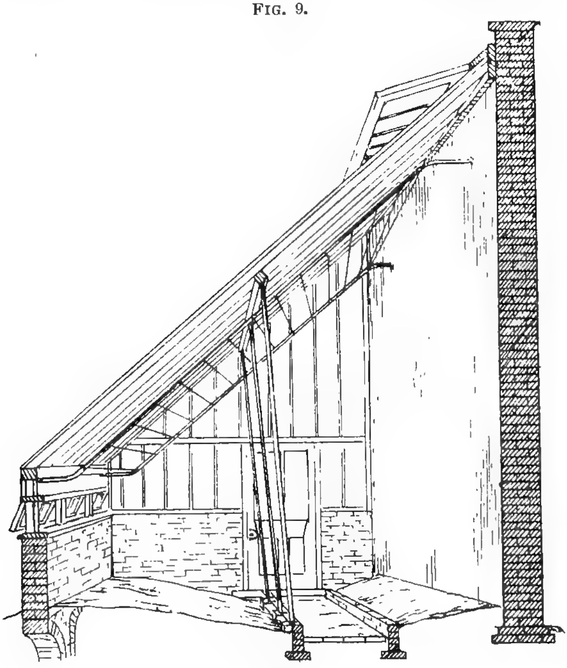


FIG. 10.

the best growers now find that the plants do better in structures from 15ft. to 20ft. in width, with about a 13ft. rafter. Very little ventilation is necessary, and this only along the ridge.

Vineries may be of almost any form or size, but in order to produce heavy crops, roomy and lofty structures are necessary, with a rather steep pitch of roof. Plenty of roof ventilators should be provided, also the means of admitting

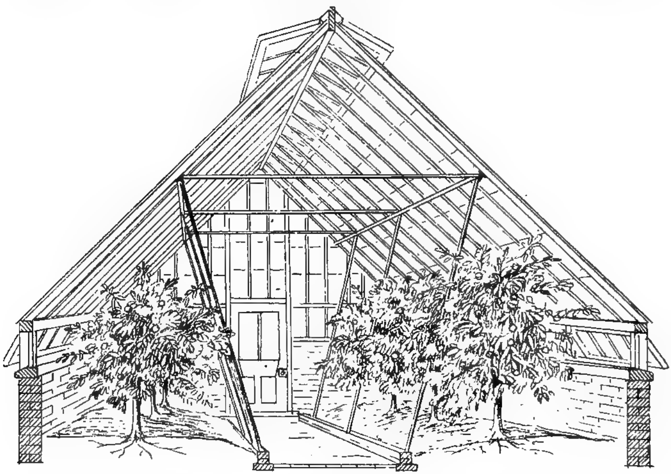


FIG. 11.

air along the sides or front, to a moderate extent. Early vineries, in particular, ought to be constructed with steep roofs, in order to catch the sun while it is still low in the sky (see Figs. 9—span, and 10—lean-to).

Peach-Houses should be very light and airy structures, with steep roofs and plenty of large ventilators both along the apex of the roof and at the sides. Peaches and nectarines also are frequently trained on a stout wire or other trellis, a moderate distance from the glass—18in. to 2ft. is the correct distance—but they may be just as well grown in the tree or bush form, this being more natural to the plant as well as more easily managed. Fig. 11 shows a good type of a span-roofed structure, planted with low-standard or "bush" trees. It is always an advantage if the sides, roof, or both, of a peach-house can be removed entirely after the crop has been gathered, in order to ripen the wood thoroughly.

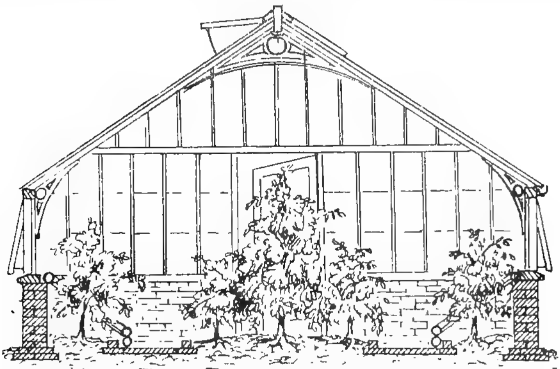


FIG. 12.

This is accomplished by filling in between the timbers with glazed sashes, fastened in place by means of buttons or screws, where not hung, so as to act as ventilators ; in this way they are easily removed when desirable.

Roses.—The house for roses should be fairly wide an very well ventilated, but not too lofty, in order that the plants may be fairly close to the glass. A good type of rose-house, where the plants are to be set out in beds or borders, is shown in Fig. 12. For roses in pots, for forcing, a house of almost any kind, if well heated, will do, provided only that it is sufficiently light and not too lofty.

Chrysanthemums. — These also best succeed in a moderately roomy, airy, and well ventilated structure ; but the plants should not stand too far from the glass, as those of the incurved varieties in particular frequently do not expand their buds properly unless these are within a short distance of the glass. Hence, a similar class of structure to that described for tomatoes will suit chrysanthemums

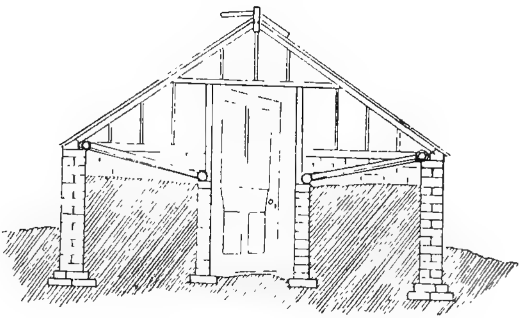


FIG. 13.

admirably, and, indeed, houses that have been cropped with tomatoes during the summer are frequently utilised for housing and flowering a batch of the former plants in the autumn, after the "toms" are over and have been cleared out. The plants may be stood on boards or stout slates, or on a bed of ashes put down on purpose. Where structures that would otherwise be suitable and useful for housing chrysanthemums in the autumn are fitted with staging, to accommodate pot-plants of any kind during the summer, this (the staging) should be constructed so as to be easily taken down and removed. This is a simple matter, whether wood or iron be employed ; the plants can then stand on the floor, as shown in Fig. 16, p. 27, and when past flowering the staging can be brought in again and refixed.

Useful types of ordinary green or plant houses are shown in Figs. 13 and 14. That illustrated in Fig. 13 is more

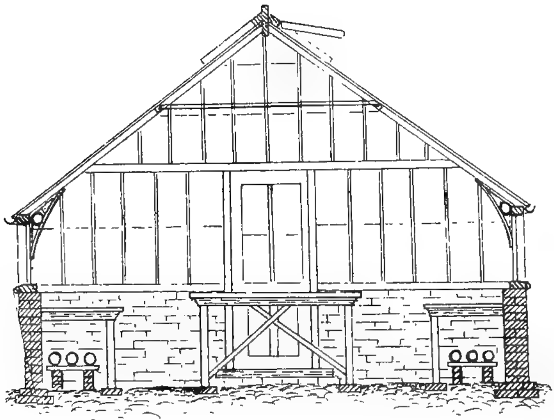


FIG. 14.

suitable for small plants, such as ordinary "geraniums," primulas, fuchsias, etc., or for "bedding" plants. As will be seen, all stand comparatively near to the glass, and the roof being low, the heat is made the most of. That shown in Fig. 14 is better adapted for large or specimen plants, such as azaleas, fuchsias, bouvardias, or begonias, etc., the larger specimens occupying the central stage, and the smaller ones the side benches.

Begonias.—These require to be grown in very roomy, light, and airy houses, and never succeed well in low, close, or stuffy structures. In hot weather they do better at a moderate distance from the glass, and a through current of air being very advisable, plenty of bottom ventilation should be provided. A rather steep pitched roof is also best. In the case of houses facing south, shade on the sunny side should be afforded by means of a moveable blind. A house suitable for begonias in summer will answer capitally, if well heated, for flowering bouvardias or tree carnations in during the winter season.

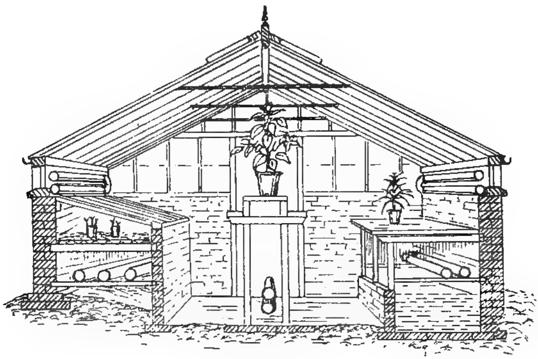


FIG 15.

Stove Plants.—Low growing plants such as gloxinias, gesneras, achimenes, coleus, poinsettias, etc., succeed well in low and rather flat span-roofed houses, such as that shown in Fig. 15, with plenty of heating power. Tropical subjects of taller habit, including large palms, musas, bamboos, ferns, also large specimen dracænas, crotons, and so forth, need a loftier structure, of course, but of the same type. But little ventilation is usually required in such structures, especially if lofty; yet it is usual to fix a moderate amount of ventilators along the apex ; bottom or side ventilation is unnecessary in such houses.

Ferns.– These may be grown well in almost any kind of house, if fairly low, close, and of a naturally moist rather than a dry nature.

Orchids.—Before constructing a house for any particular class of orchid, a skilful expert in their culture had better be consulted. The temperate Odontoglots, such as the popular O. Alexandræ, thrive best in a cool, airy, and lightly shaded structure, such as one suitable for begonias or the pretty little streptocarpus. The species mentioned succeeded admirably, in the writer's experience, in a spacious three-quarter span structure facing east, lightly shaded during the middle of the day only by some lofty trees growing near the southern end, but receiving the nearly full benefit of the sun in the morning and evening. Most of the dendrobiums will thrive in a low, warm, span-roofed structure running east and west, shaded on the south from powerful sun, and ventilated chiefly by means of openings arranged along the sides. For a large number of the more commonly grown orchids of an intermediate or temperate character, a well heated structure, such as that illustrated in Fig. 15, and suitable for bouvardias,

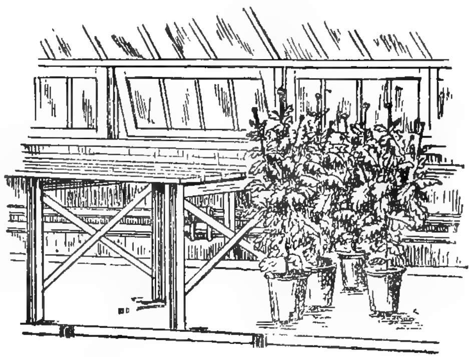


FIG. 16.

etc., will be found extremely suitable. An illustration of a fine example of orchid house is given in Fig. 67 (pp. 88, 89).

With very few exceptions, greenhouses of all kinds should be erected, as far as possible, in open positions, *i.e.*, away from the shade of high trees, lofty buildings, or the like. Though in hot summer weather a little shade is often desirable and even beneficial, as a rule, plants of all kinds under glass require all the free light and sunshine they can get in our none too sunny climate. Unless the plants receive plenty of free light on all sides, the growth of most descriptions is sure to be more or less weak and spindly, with an absence of that freedom of flowering that is so important a point in the growth of plants for market in particular.

From what has been stated above, it will be seen that the chief points to be considered in the construction of glass-houses for various purposes are :—(1) Proportions ; (2) Pitch ; (3) Ventilation ; and (4) Temperature, or heating power.

Proportion.—As regards the first, sufficient has already been said, probably, to show under what conditions, or for what purposes, large or spacious structures should be preferred to those of smaller proportions, and also the approximate widths, etc., usually adopted by the best growers for the different subjects. But beyond this, it may be as well to say here that houses of considerable dimensions possess certain advantages over smaller ones, and for many purposes are decidedly preferable. For one thing, they do not become cool nearly so rapidly as small houses, at least when closed, and although under the influence of sun the temperature rises nearly or quite as rapidly, yet in hot or bright weather they do not become nearly so close and stuffy as smaller, lower structures, as the superheated air rises to the apex of the roof, leaving the lower part cool. The temperature in such structures is consequently much more even and regular—a most important matter in the successful culture of many kinds of plants. On the other hand, plants of low growth must stand at a considerable distance from the glass in such large structures, and this is usually considered by most growers to be a disadvantage, but if so constructed as to admit a maximum of light, and at the same time freely ventilated, it will be found that plants will not, as a rule, become "drawn" or "run up" to nearly the same extent in such houses, even when standing far from the glass, as they would do under similar conditions in smaller structures—that is to say, provided that they are not unduly crowded.

Again, plants growing far from the glass, in spacious houses, will neither become scorched or "scalded" in sudden bursts of strong sunshine as they are very liable to do in small ones, especially if air is not given promptly, nor are they so likely to suffer from frost in cold weather as they would be if standing closer to the glass. On a sharp night, it is those nearest the glass that are "nipped" first—and worst.

Lastly, large houses may be heated to and kept at the same temperature with less piping, proportionately, and consequently with less fuel, than small ones, the radiating surface being smaller in proportion to the cubic contents.

Pitch.—The pitch of roof next demands consideration. Generally speaking, greenhouses of all kinds are now constructed with flatter or lower-pitched roofs than they were a quarter or half a century ago. In a structure with a high pitched roof the upward current of air, when the roof ventilators are open, is much sharper than in a low or flat-roofed house, and consequently the evaporation is more rapid, and the atmosphere is on the whole considerably drier. It is also plainly evident that to construct a steep-pitched roof, more materials (glass and wood) will be required for a house of the same width than if a lower pitch were adopted, owing to the greater length of rafters. On the other hand, a very low pitched roof, though economical as regards material, and very suitable for many subjects, not only requires a good deal of support, but is much more difficult to tie together securely than one constructed with a sharper angle. Again, snow does not slide freely from a very flat roof, and when there is a heavy fall the excessive weight often causes serious damage, and lastly, houses with low-pitched roofs are always more liable to "drip" than if the angle is steeper.

For the usual run of greenhouses intended for ordinary purposes, a pitch of about 45 degrees is a fairly suitable one, especially where the width is not great. This is, indeed, an excellent average pitch for vineries, tomato-houses, peach-houses, and so forth, but for the majority of ordinary plant-houses, rose and fern-houses and so forth, 40 degrees is undoubtedly preferable, and for cucumbers, stoves, houses for gardenias, stephanotis, palms, etc., as well as in the case of propagating and forcing-houses, generally 35 degrees may be taken as a safe and reliable figure. In some cases, roofs as low as 30 degrees are constructed, but so flat a pitch cannot be recommended for very wide structures, and below this it is never advisable to go.

Structures with roofs at an angle of 50 degrees or more from the horizontal, though common many years ago, are now seldom erected, or seen, but in the case of necessarily narrow lean-to houses against high walls, intended for the culture of peaches, vines, or tomatoes, &c., a pitch of 50 tc 60 degrees, or even more, may be advantageously adopted, as affording an extra length of rafter. Such steep roofs also catch the full force of the sun when this is low in the sky, in the winter and early spring, when it would be reflected to a greater extent from flatter ones. (See Fig. 17).

The length of the rafter is in all cases equal to the secant of the angle or pitch.

The Ventilation.— This is another point requiring careful consideration and proper provision.

Unless the internal atmosphere of a greenhouse of any kind is at any rate occasionally changed, the health of the plants it contains will probably suffer, sooner or later, though as already stated certain classes of plants require much more "air" than others. Such plants as pelargoniums (geraniums), primulas, marguerites, and

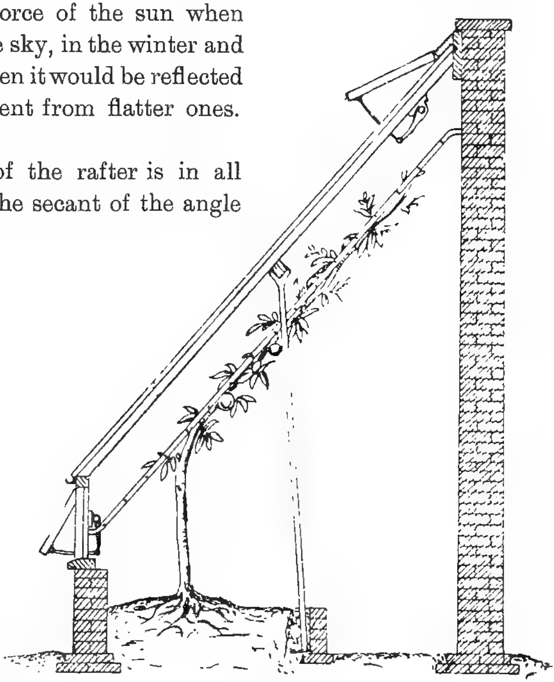


FIG. 17.

other "cool-house" subjects, as well as tomatoes, roses, the entire race of what are termed "hard-wooded" plants—*i.e.*, camellias, azaleas, heaths, epacris, and so forth—need to be freely ventilated at almost all seasons of the year, while on the other hand, cucumbers, with palms and many other tropical or "stove" plants, rather enjoy a confined atmosphere than otherwise, and structures intended for the culture of anything of the kind do not require to be provided with so many or so large ventilators as houses constructed for any of the other subjects mentioned above. It is always advisable, notwithstanding, to provide for a moderate amount of ventilation, as any house of any kind may of course be required at some future time for a different purpose, and it is at all times as well to have the means of admitting air freely if necessary.

Houses constructed in the old-fashioned style, with numerous small squares of glass and consequently innumerable "laps," do not as a rule require nearly so much ventilation as structures of the modern type, built with larger squares and few laps, and comparatively speaking as "tight as wax" when closed. In the former, an almost constant current of air is passing through the numerous laps, more particularly in windy weather, and the necessity for artificial ventilation is of course considerably reduced thereby, whilst in very close or "tight" houses, the ventilators must be carefully managed if sudden and violent changes in the temperature and atmospheric moisture are to be avoided.

Two sets of ventilators are usually provided, one placed along the ridge or apex of the roof, and another along the front or sides of the house. In the case of a lean-to structure, it is evident that only two rows or sets of ventilators can be employed. The span-roofed form (which from a constructive point of view practically consists of two lean-to's placed back to back) admits of four rows—one on each side of the ridge and one along each side—while in the three-quarter span three sets are necessary, or at any rate desirable.

The simplest, commonest, and on the whole best form of roof ventilator is that of the flap, which may either be glazed, or in the case of cheap structures consists merely of two or three lengths of match boarding joined together. The whole is hinged to the ridge-plank, or in some cases to a separate "hanging-piece," and opened by means of a casement-stay and pin, or by a lever or with a rod, eye, pulley and cord fixed to its lower edge (see Fig. 18).

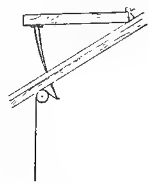


FIG. 18.

In the Worthing district, where an immense area of glass is devoted to the culture of grapes, tomatoes, cucumbers, etc., for market, the roof ventilators are almost invariably constructed to contain three squares of glass of the same size as that employed in the roof itself, the usual size (of the glass) being 20in. by 16in. Each ventilator consequently covers four rafters or sash-bars, the styles, of course, overlapping the two outer rafters a little way. Where this class of ventilator is employed, they should be hung alternately on each side the ridge (in span-roofed or three-quarter span houses), with a space between each, on the same side, equal to the length of a ventilator, or three widths of glass (between the bars). See Fig. 19. For cucumber or forcing-houses, double the above distance between each ventilator will suffice, but it is at all times advisable to provide for plenty of ventilation rather than too little.

Where a superior class of house is required, and a little extra expense is no object, continuous ventilators along the ridge will be found decidedly preferable to those already described, as well as affording a much more pleasing appearance. (See Fig. 20.) These are constructed in much the same manner as the

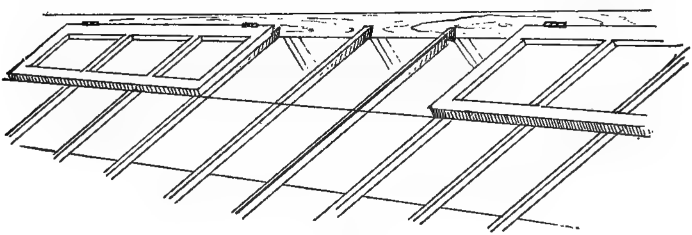


FIG. 19.

others, but are framed together in long lengths of 12ft. to 20ft. or so, and 18in. or 2ft. in width. They may be rebated together at the ends, to prevent any leakage, if desired, and if fitted with proper gearing can be opened or closed along the whole of one side of the house, however long, at once. Of course, these should be fitted along both sides of the ridge in whole and three-quarter span houses.

Years ago, sliding roof-ventilators were very generally employed, though they appear to be almost out of date now. In the cases of roofs constructed with framed lights and heavy rafters, it is a very simple matter to make the upper half of every alternate sash or bay to slide up and down in suitable guides, each being fitted with a pulley and cord. Even where the roof is made without sashes, the spaces between the principal rafters being filled in with light bars and glass, as described on p. 17, a sliding light may be fixed in every second or third bay. The disadvantages of this plan are that heavy rafters and a good deal of sash-work are required, which of course add to the expense, while the

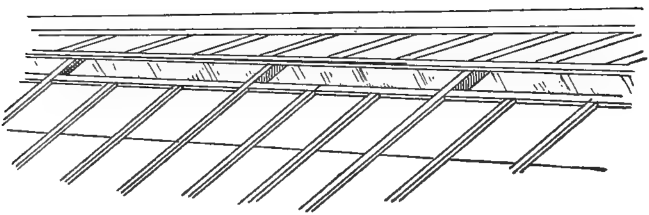


FIG: 20.

sashes cannot be opened in wet weather without admitting the rain.

Ventilators made the whole length of the rafters, and hinged at the *bottom* instead of the top, are occasionally made use of, as is also a type consisting of a long narrow sash, usually the width of a single roof-square only, and hinged at one side (Fig. 21), but none of these forms are as effective as the ordinary flap-ventilator hinged to the ridge-plank.

Cheap, low houses intended for the growth of bedding-plants, carnations, and so forth, may be ventilated at the ridge by fixing a length of light quartering along each side of the ridge-plank, parallel with and 6in. or 8in. from it. These, cut into suitable lengths, may be supported by means of light "principal" rafters, placed 3ft. or 4ft. or so apart—3in. by 2in. stuff will do for these, if the house does not exceed 10ft. or 12ft. in width. The longitudinal spaces thus left on each side the ridge may be covered in with 7in. or 9in. boards, with a cross-brace screwed on here and there to prevent warping, hinged to the ridge, and fitted with small casement stays. These are easily opened and closed, and admit the air more evenly all along the house, though they of course obstruct the light to a certain extent, but where placed directly over a narrow central pathway, this is not a matter of any great importance.

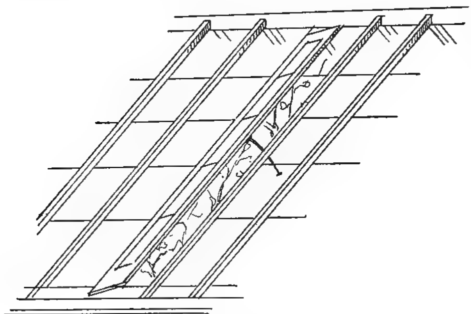


FIG. 21.

In the successful culture of tomatoes, peaches, chrysanthemums, and greenhouse plants generally, air must also be admitted at the bottom of the house at certain times, and even vineries are the better for a moderate amount of "side-air" in very warm weather; while towards the end of the season, when the fruit has been gathered, and the object is to get the wood thoroughly matured, vines and other fruit trees cannot be too freely exposed to the influence of fresh air. As already stated, however, front or side ventilators are not required in cucumber-houses, yet it is advisable to put in a few small ones at intervals, for the reasons already stated.

In structures of the better class, this is usually provided for by putting a wooden framework, from 1ft. to 3ft. or more in depth, on the top of the side walls, such framework being fitted with glazed lights or sashes, either fixed, or hung from the upper plate, or rail, to be opened and closed at will, and thus admit air more or less, when required. This plan necessitates the employment of two "plates"—the upper or eave-plate (A in Fig. 6), which carries the rafters, and a lower one, or "sill" (B in the Fig.) ; but it is decidedly the best system, and affords a very handsome appearance, when properly proportioned.

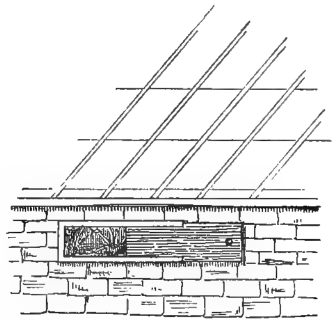


FIG. 22.

Louvres.—Another method of admitting air at the bottom, and applicable to houses in which there is no glass at the sides or front, is by means of what are termed "louvres." These are really wooden boxes built into the side walls, a few feet apart, and fitted with sliding doors or hinged wooden flaps (usually the latter), to enable them to be opened or closed at will. (See Fig. 22.) This system has been almost universally adopted by the Worthing growers, but though inexpensive, and, to a certain extent, effective, the louvres possess several disadvantages.

The usual size of these louvres is about 3ft. in length (equalling four bricks), by a depth or width of 9in. or 12in. (three or four courses respectively) over all, and in order to enable them to be fixed well above the ground level, the walls are usually built 3ft. or 4ft. in height. The "stuff" of which they are made should, of course, be of the same width as the thickness of the wall, *i.e.*, usually 9in., and if not built in at the time they may be fixed afterwards by means of wedges, filling and pointing them all round with cement subsequently.

The disadvantages of the louvre are that when opened there is a draught of air opposite each, but little or no current in the spaces between; secondly, they admit no light at all when closed, and very little when open; thirdly, they have a very unsightly appearance, while lastly, where several long houses are fitted with them, the necessary opening and closing occupies a lot of time, and they cannot very well be fitted with gearing of any kind.

There is yet another method of admitting air at the bottom or sides of a house—a kind of compromise between the two already described—and an excellent one where plenty of air is required, and yet it is desired to avoid the expense of sashes, etc., though in this case also a double "plate" is necessary. This is to fix a continuous row of comparatively narrow wooden flaps, hinged along their upper edges, in a suitable framework, on the top of the brickwork, as shown in Fig. 23. A 9in., or 12in. board, 1in. or $1\frac{1}{4}$in. thick, cut into lengths of 4ft. or 5ft., strengthened by a couple of cross braces apiece, and hung between the two plates, will answer admirably.

For small structures, or where only a small amount of bottom air is required, even ordinary 7in. floor boards will be found quite sufficient. These may be hung with Paine's

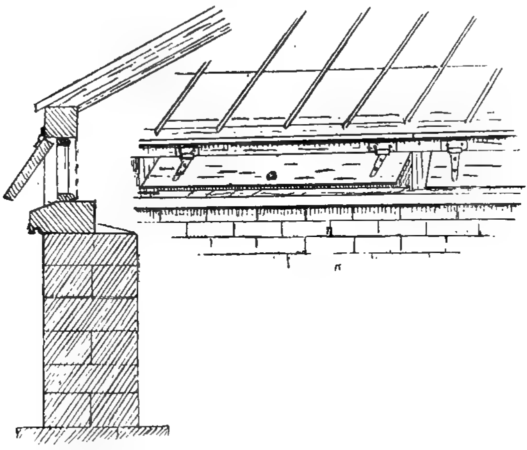


FIG. 23.

or Piper's patent hinges, and opened and closed by means of small casement stays, with a button to secure each when closed, or gearing may be fitted to them, but in this case short arms and levers should be employed.

I have used ventilators of this kind in several instances with great success and satisfaction; they occupy but little room, and at the same time admit abundance of air, while they present a very neat and pleasing appearance.

Bottom ventilators, or "louvres," are occasionally fixed in the side-walls *below* the staging, whether there are any glazed or other ventilators above—on the top of the wall—or not. In this way, air may be admitted without its acting directly on the plants, and in cold weather dangerous draughts or chilly air are thus avoided. Houses for pelargoniums, begonias, and other plants that enjoy a free current of air through them may be advantageously constructed in this way, and for some descriptions of orchids this is also a very suitable method. If there are hot-water pipes beneath the staging, air admitted thus will be warmed before it reaches the plants, especially if there is another wall, also fitted with openings, next the pathway, as shown in Fig. 24.

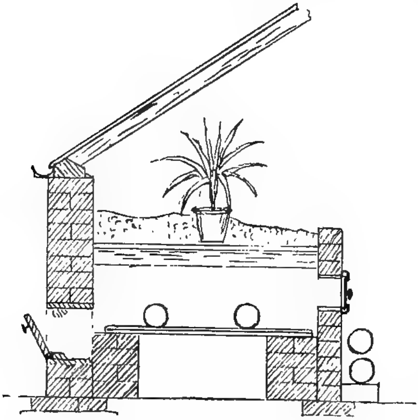


FIG. 24.

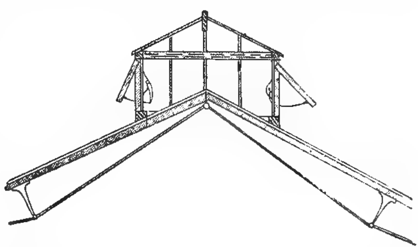


FIG. 25.

In large and lofty conservatories, or where a very ornamental appearance is desired, top ventilation is frequently provided for in the method shown in Fig. 25. In this, there is what is termed a super-roof, with ventilators that are opened and closed by means of pulleys and cords, or by means of lever gearing.

In what are termed tenant's fixture greenhouses, the sides must necessarily be constructed entirely of wood, or wood and glass, any brickwork or concrete constituting it a (landlord's) fixture. "Tenant's fixtures," if simply resting on a row of loose bricks (to keep the timbers off the soil), and not fixed to the ground in any way, are the property of the tenant, and can be removed by him at pleasure.

CHAPTER III.

WALLS, FOUNDATIONS, ETC.

THE majority of horticultural structures, and certainly all those of the better class, are built on low walls of brick, stone, or concrete—usually the first. The sides of tenant's fixtures, and other cheap houses are, however, frequently constructed of wood, and it has been stated in support of the use of this material that a 1in. board will exclude as much frost as a 9in. wall. Wood is an excellent non-conductor of heat, we know ; but, though possibly correct in theory, this will hardly stand the test of practice. Beyond this, boards have a nasty knack of shrinking and gaping at the joints, as well as of cracking under the influence of heat and drought ; and when this occurs, a current of air is set up directly, and away goes all the atmospheric moisture, usually when it is most required.

In low, cheap structures, intended for the growth of comparatively hardy and air-loving subjects, such as carnations, "geraniums," primulas, etc., and especially where the house is wide and the walls low and of an inconsiderable area, wooden walls or sides answer well ; but all structures of a substantial and permanent character, and more particularly those intended for forcing, or in which a high temperature is to be maintained, must be constructed with walls of brick or some other solid and impervious material. These retain both heat and moisture in a way that no wooden walls can do, however carefully constructed.

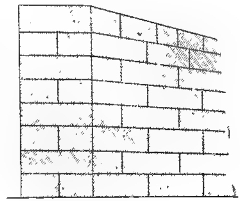


FIG. 26.

Bricks are, of course, most commonly employed for all work of this kind, but where stone is plentiful and cheap, it may be used with equally good results ; and concrete, composed of either coarse gravel or burnt "ballast" is also a very suitable material.

As a general rule, the walls of a greenhouse of any kind, even if of small dimensions only, should not be less than 9in. in thickness, *i.e.*, consisting of two bricks laid lengthwise of the wall, or what bricklayers term "nine-inch work" (see Fig. 26). Very low walls, of not more than about 18in. in height may be built of a single brick in thickness, or "4½in. work," but in this case cement mortar should be used, and a pier had better be put in every 3ft. or so, either inside or outside. Walls of this thickness, thus strengthened with piers, may be as much as 2ft. in height, but if more than this, 9in. work should be employed throughout. If the piers are built outside, they may be very conveniently utilized to carry the guttering (see Fig. 27). Where bricks are employed, it is easy to calculate the number required to construct a wall of any given size and thickness. An ordinary brick, when set, measures as nearly as possible 9in. in length by 4½in. in breadth, and 3in. deep, so that four

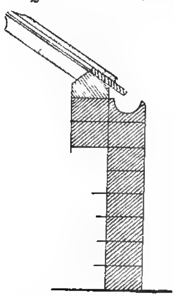


FIG. 27.

"courses" make just a foot of wall in height. Thus, a piece of 9in. wall, 50ft. in length by 3ft. high, would require $50 \times \frac{4}{3} = 66\frac{2}{3}$ or, say, 67 bricks in a single row; multiply this by 12, the number of courses, and again by 2 for the double thickness, and the result is 1,604 bricks. Of course, a small allowance must always be made for waste and breakage. There are several different ways of laying bricks in a 9in. wall. The "old English bond" consists of a "header" and a couple of "stretchers" laid alternately in every course, but the "stretchers" in one course must come exactly over the "headers" in the one below. Then there is the Flemish bond, the Yorkshire bond, and others; but

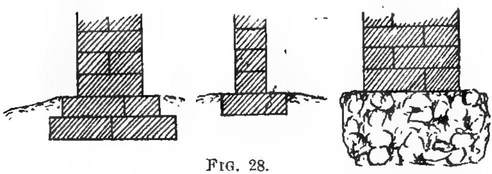


FIG. 28.

for greenhouse work as good a method as any is to lay alternate courses of "headers" and "stretchers," but always making the top course one of "headers," and, if possible, using a little cement in the last course or two, to make a sound job. In all brickwork, a joint in one course must never occur exactly over one in the next below.

It is, however, necessary to have a "footing" of some kind before commencing a wall of either brick or stone. This may consist of one, two, or more courses of rough bricks laid in a shallow trench, each being a brick wider than the one above it (see Fig. 28). Concrete footings made with rough gravel, stones, or "ballast" (burnt clay), mixed with hot lime and water, are frequently employed for greenhouse work, and answer admirably, but one "wide" course had better be placed on it. A trench about a foot wide and 9in. or 10in. deep is taken out and filled with the freshly mixed concrete, this being well rammed down and levelled, and when "set" the brickwork may be commenced.

In some parts of the country brickwork is done by the "square," a square being a piece equal to 10ft. square, or 100 square feet, and a square of 9in. work contains 1,066 bricks. Good "stock" bricks can usually be obtained for from 25s. to 30s. per 1,000, and the average cost of a square of brickwork, including mortar and labour, is from 40s. to 50s. Good lime mortar ought always to be used, and if fresh and "hot" when used so much the better. If the bricks can be soaked or wetted before use the mortar will take a better hold and bind them very securely together; a very little Portland cement mixed with the mortar causes it to set as hard as iron, and make very sound work.

Where stone is plentiful and cheap this makes just as good a wall as bricks, but a stone wall should be somewhat thicker than a brick one—15in. or 18in. instead of 9in.—and if rough stones are used the mortar must be very good. Cement mortar is best. Good concrete also makes a capital wall for the purpose under consideration, but plenty of cement must be used in order to make sound work; it is very false economy to be too sparing with it. Portland cement is now much cheaper than it used to be, and can be bought in large quantities at a very low rate; but a great deal of both this and labour is required in concrete work, and where good sound bricks can be obtained for about 25s. per thousand, or less, brickwork will be found but little if any more expensive than the other.

When there are any louvre boxes or ties for the plates (see p. 53) to be worked in, these should be thought of and placed in time, as any omissions of this kind means pulling the work to pieces and a lot of waste of time and labour afterwards.

Concrete walls should also be made quite 10in. to 12in. in thickness—preferably the latter. The concrete is, of course, kept in place while setting by a lining of stout boards placed on edge on both sides, and supported by means of pieces of stout quartering and ties across the top. Where the soil is clayey, plenty of "ballast" may be made by burning a quantity of the former in a heap, with small coal or "slack," and when burnt through and getting cool the whole is screened, the moderately coarse part being mixed with plenty of Portland cement, or lime and cement mixed, and water, to form the concrete. The boards must not be removed until the concrete is thoroughly set.

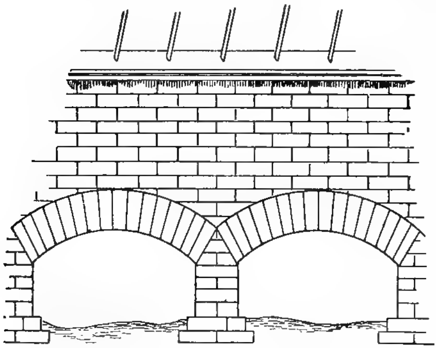


FIG. 29.

Spaces for the doorways, etc., must be left beforehand when building with concrete or rough stone in particular, as neither of these materials can be knocked about and made good again like brickwork.

In the construction of vineries, if the vines are to be planted inside the house, the roots should be able to run outside as well as in the borders inside, so that a border must be made outside as well. To enable the roots to reach this, the walls are frequently built on low arches, as shown in Fig. 29, the crowns of the arches being just below the surface of the soil, when the beds are made up. But brickwork of this kind is expensive, and if the walls are built with only shallow footings, the roots will usually find their way out all right. It is, perhaps, better, however, to put a couple of feet of "pigeon-holed" brickwork in below the ground level, or if some good flat stones are at hand, a row or two of rough arches may be built below the surface (Fig. 30).

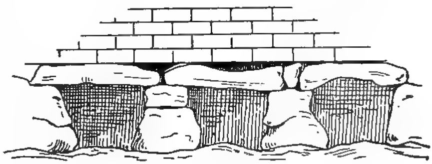


FIG. 30.

Where the sides, or walls, are to consist of wood, a good method of going to work is to drive or sink stout square posts in the ground to a depth of 18in. or 24in., and 3ft. or 4ft. apart, and mortice or simply "spike" the plates on to the upper ends of these posts or uprights. Of course these must be fixed exactly in line, and all the tops cut perfectly level and true before putting the plates on. It is also a good plan to give all such posts a good coat of tar, or what comes to much the same thing, to just char the lower ends all over rather higher than they will be sunk in the ground, before putting them in place. This will cause them to last infinitely longer than if used without any preparation. A lining of 1in. or ¾in. boards (tongued and grooved) should be nailed on outside, and another lining or "skin" of rather thinner material put on inside the posts, will render the structure much "tighter" and warmer. The space between the two "skins" may be fitted with sawdust, which being a capital non-conductor, will exclude more cold than a brick wall.

A very inexpensive and useful span-roofed structure, suitable for carnations, roses, tomatoes, pelargoniums, and bedding plants generally, may be constructed by driving in uprights along each side and fixing the plates on to them, as above; but instead of a double lining of boards, simply nail on one or two rows of stout 6in. to 9in. boards, previously well tarred, on the outside. If side-ventilators are required, nail the lower row, or rows, on only, and cut the upper one into lengths, corresponding to the distance between the uprights, and hang them to the plate by means of Paine's patent joints (see Fig. 53). Tack a thin fillet, 1½in. or 2in. wide, along the bottom of each flap, outside, so as to overlap ¾in. or so, and make a tight joint, and screw a button on so as to secure each length when closed. If the plate is fixed on the uprights so as to overhang them by the thickness of the boards, these will go on flush with the former, and a thin fillet tacked on all along over the joints will prevent any draught, and make a tight job of it. A row of loose bricks had better be laid along the bottom for the lower edges of the boards to rest on and keep them off the ground. These (bricks) may be banked up slightly and made tight with some ashes or rough mortar put on outside. Such a structure, with a sunk pathway along the centre, and the beds raised only a few inches above the general level of the ground outside, will contain a quantity of growing stuff, with a very small cubic capacity, and if not more than 10ft. or 12ft. in width, may be sufficiently heated by means of a single row of 4in. piping running all round the house only.

CHAPTER IV.

THE WOODWORK.

THE principal parts of woodwork employed in the construction of greenhouses, as shown in Fig. 31, are as follows: the wall, or eaves-plates, A; the rafters, B; the ridge-plank, C; the purline, D; the standards, E; the venti-

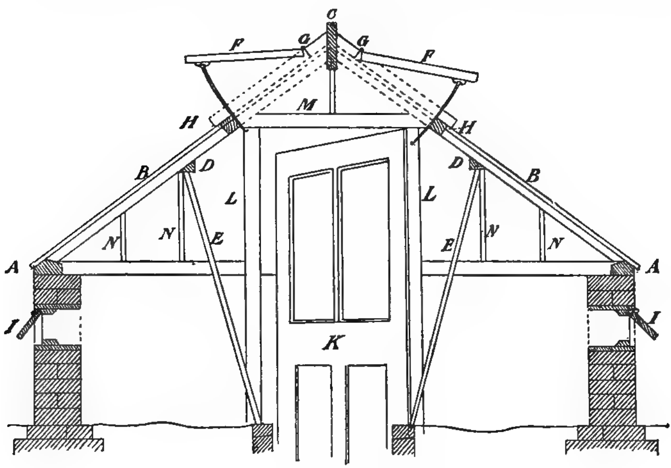


FIG. 31.

lators, F; the hanging pieces, G; the seats, H; the louvrés, I; and in the ends—the door, K; the door frame, L; the transom, M; and the end bars, N.

Wall-Plates.—The proper sectional form for an ordinary wall-plate, to rest on a brick or other wall, and carry the lower ends of the rafters direct, as shown, is illustrated in Fig. 32. It will be seen that the upper surface is bevelled or champfered off both inside and out, the inner face being both wider and flatter than the outer one. The plate is thus bevelled in order to throw off all moisture and prevent decay. The outer bevel should be of the same angle as the pitch of the roof, as shown. For houses of moderate size, say 10ft. to 15ft. in width, the wall-plates should be of 5in. by 3in. stuff at the least ; 4in. by 3in. will do for small structures, but in wide structures (20ft. to 30ft.), or when great solidity is required, plates of 6in. by 4in., or even larger stuff, are frequently employed.

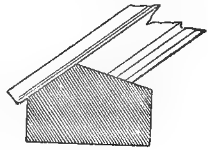


FIG. 32.

The correct form for the upper and lower, or sill, plates, where the sides consist in part of glass, is shown in Fig. 33 ; the *rebate* or shoulder, shown at A, may either be worked in the stuff, as shown at B, or formed by tacking on a stout bead or fillet afterwards, as at A. The groove shown at C is provided to prevent any water running down the face of the wall below, or soaking in beneath the plate. This must, of course, overhang the wall about $1\frac{1}{2}$in., as shown in the sketch. The upper plate is square in section, as shown at D, with a rebate or fillet on the under side.

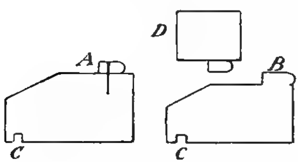


FIG. 33.

When several lengths of plates are required, they should be halved together, as shown in Fig. 34, each joint being cut from 8in. or 9in. to 12in. in length, according to the size of the stuff. To make a joint of this kind truly, run the marking guage—set to the exact half of the thickness of the

Fig. 34.

quartering—along each side and across the end, and then mark with a square across the end of the piece to be cut out. Now cut about half-way down on *one* side with a rip-saw; reverse the timber, so as to prevent the saw running at all, and cut down from the other side. When the saw has run far enough, cut the piece off across the base, slanting the saw very slightly *inwards*, so as to make a close joint. Give each face a thick coat of paint or Stockholm tar, and secure with about five stout screws.

End-plates are made as shown in Fig. 34, the rebate, to take the lower ends of the squares of glass, being placed outside. These, and the side- or wall-plates, are also halved and screwed together at the corners, and here the latter must *overlap* the end-plate, so that the end rafters may be properly fitted and secured at the base.

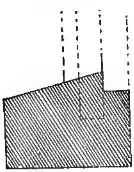


Fig. 35.

When all have been fitted, the plates, which are usually left rough on the under sides, should be well bedded in good lime mortar—or a mixture of mortar with a little Portland cement may be used—on the top of the walls, driving them down well with a mallet, where necessary, until the spirit level shows a perfectly flat and even surface.

It is as well to place a piece of wood between the mallet and the timber in all work of this kind, to prevent any bruising of the latter.

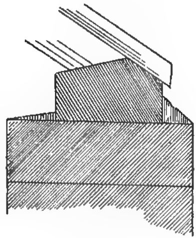


FIG. 36.

Ordinary plates, for both sides and ends, are usually fixed "flush" (*i.e.* level or even) with the outside face of the walls, though it is a good plan to draw the former, at any rate, in an inch, in order to allow of a line of cement being run along afterwards (see Fig. 36). This helps considerably to keep the plate from shifting. In some cases, however, the plates are fixed flush with the *inside* of the wall, and when this is done, the gutter is usually bedded in mortar or cement on the outer course. But this plan has a somewhat clumsy appearance, and if there is any leakage or overflow from the gutter, the wall is always wet, and soon gives way. Bedding the gutter on piers built outside the wall proper is quite another thing. Lower or sill-plates must always overhang the face of the wall by 1in. or $1\frac{1}{2}$in., so as to allow the drip to fall clear of the wall.

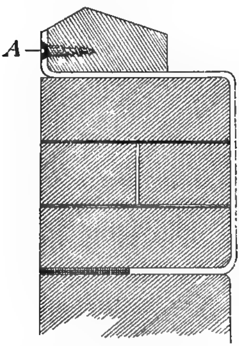


FIG. 37.

Various methods are employed to counteract the thrust caused by the tendency of the weight of the bars and glass to force the wall-plates outwards. Where the feet of the rafters rest directly on the wall, or rather on the wall-plates, a good method of securing these last is to build into the wall pieces of flat bar-iron bent to the form shown in Fig. 37. A hole is drilled at A, and a screw put in. One of such holdfasts placed every 5ft. or 6ft. will effectually prevent the plate from shifting, or if it does the wall must go too. If the iron is just let in to the plate at A, a neater appearance will be afforded.

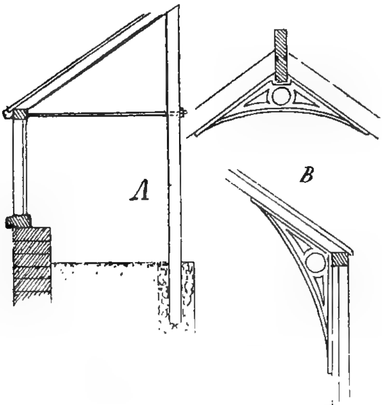


FIG. 38.

Another way is to secure the plate at intervals by means of a round iron rod passing through the plate. and through a standard supporting the purline, with a head at one end and a thread and nut at the other. If iron standards are used, or it is not considered desirable to weaken wooden ones by making holes through them, an iron strap or collar may be passed round each, and tightened up, as well as secured to the rod, by means of a bolt and nut, passing through a hole in the rod. This makes a very sound and good job. If there is no purline or standards, the rods may be bent down and secured to stout posts sunk in the bed or floor of the house, or to the staging if there is any.

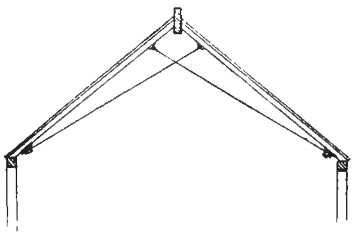


FIG. 39.

In structures with glazed sides and two plates, the upper one may be tied in by means of rods secured to the standards, by means of cast iron brackets screwed to the rafters and uprights, or muntins, at the sides, or by spandrils at the apex of the roof (see Fig. 38), all of which tend to keep the bars from giving out, and consequently keep the plates in place, or lastly by means of rods passing from the plate at the bottom to a point a little way down the rafters on the opposite side, as shown in Fig. 39. Ordinary horizontal cross-ties from rafter to rafter above will also prevent the plates giving way, but in addition to these it is as well to secure the plates directly in some way.

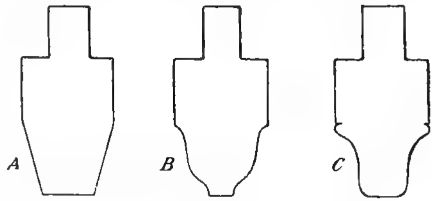


FIG. 40.

Rafters.—Plain or principal rafters consist simply of lengths of ordinary rectangular quartering, which may vary in size from 3in. by 2in. to 8in. or even 9in. by $2\frac{1}{2}$in. or 3in., according to the size of the structure and length of the rafters. In conservatories, and other ornamental structures, the principal rafters are frequently moulded more or less elaborately, or if even simply champfered at the corners, their appearance will be improved considerably.

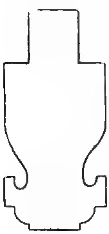


FIG. 41.

Sashbars, of which the larger sizes are frequently used in place of rafters, but taking the glass direct (see p. 17), are made in several sizes and patterns, some of which are shown in Fig. 40. The strongest, simplest, and best form for ordinary purposes is shown at A; but where an ornamental appearance is desired either of the others may be chosen. The form shown at Fig. 41 is Tucker's patent anti-drip roof bar, designed for use in orchid houses, etc. The 3in. by 1½in. size of A pattern will safely carry a roof of even 21oz. glass up to 7ft. or 7ft. 6in. in length (of rafters) even without a purline, and up to 9ft. or 10ft. with this aid. In exposed or windy localities it is, however, safer and better to employ the 3in. by 2in. size, which will easily carry the heaviest roof up to 15ft. or so, with a purline, or to 10ft. or so without, the bars not being more than 16in. to 18in. apart. It is, however, always the best and safest plan to put a purline and standards in, however stout the bars may be, certainly where the rafters are long; but if principals are employed a purline is seldom necessary.

As regards the various methods of constructing the roof, sufficiently full detailed instructions have already been given on pp. 17 and 18, so that very little remains to be said upon that part of the subject here. Houses constructed entirely, or principally, of framed lights or sashes, possess one rather important advantage over those built of bars and glass in the ordinary way, in that should the necessity for removing them ever arise, they are easily taken apart and reconstructed, while, in pulling the others down, a good deal of glass is almost sure to get broken, and the ends of the bars have generally to be re-cut before erecting again. Consequently, houses of the more portable type are really more valuable than the others.

When cutting the ends of the rafters or sashbars, much the best method is to use a mitre-box, made beforehand to the right angles, one for the top and one for the bottom.

These angles can be obtained either from the working plan, if on a sufficiently large scale, or a first pair of rafters may be cut and fitted to the plates and ridge exactly, and the mitre-box be made from these.

FIG. 42.

When nailing in the bars a guage should be used to keep them at the exact distance apart to take the glass easily, yet without too much play. A bit of plain lath or bead will do, and it should be cut to a bare 1-16th of an inch longer than the exact width of the glass. This will allow of the latter going in just right, if each bar is pushed up tight to the gauge top and bottom. Only those who have tried it can know the trouble and nuisance it is to put in glass with bars $\frac{1}{4}$in. to $\frac{1}{2}$in. too far apart, and when done it is almost sure to leak badly.

The bradawl must be used in both ends of the bars before nailing, otherwise they will probably split, the smaller sizes in particular.

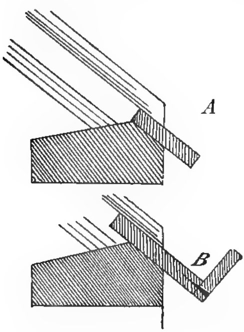


FIG. 43.

The end-rafters, which are usually made a little stouter than the rest, are worked to the section shown at Fig. 42.

Next, the construction of the eaves, and the manner in which the drip-water is carried into the gutter, needs some amount of consideration. Of course, where framed lights or sashes are used, the lower edge of the bottom rail is projected 2in. or 3in. beyond the plate, and from it the water drips directly into the gutter; but where only glass and bars are employed an arrangement of some kind is necessary. The lower edge of each square of glass may, of course, be projected beyond the plate far enough to allow of the drip falling in to the gutter; but when this is done the glass appears to be peculiarly liable to breakage, and unless each square sits down very closely on the plate, a good deal of air will find an entrance at this point.

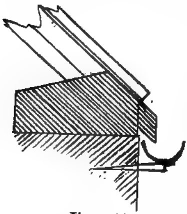


FIG. 44.

In some cases, a strip of zinc, about 4in. wide, is tacked along the outer face of the plate, overhanging sufficiently to allow of all the drip falling into the gutter. The glass is brought down as far as the edge of the plate, and, of course, overlaps the zinc an inch or two. Copper nails should be used to fasten the zinc in place.

Yet another way, and one much favoured by the growers in the Worthing district, is to tack on to the outside of the plate a diamond-shaped fillet or bead, as in Fig. 44. This supports the lower edge of the glass, and conducts the water into the gutter.

FIG. 45.

But decidedly the best method of all, in my opinion, is the adoption of a wooden "drip," consisting of a board, 4½in. to 6in. wide, and ⅝in. or ¾in. thick, fixed as shown in Fig. 43. If fixed as at A, with the upper edge flush with the ridge on the plate, the ends of the bars can be just sawn to shape, but if carried up higher, as at B, the ends of the bars must be chiselled out. This affords perfect support to the glass, and makes a very neat and tight job. By nailing a 2½in. by ¾in. batten (planed) on to the lower edge of the drip-board (as at B in Fig. 43) at right angles, and giving the whole a good coat of tar, an excellent gutter may be obtained with a very slight extra expenditure of material and labour; but in a level house, if such a gutter is of any considerable length the drip must be sloped to secure a fall, and in this case it should be cut from a wider board.

Double plates, or gutters, of cast iron are now manufactured. These, bolted on to iron uprights, or posts, are at once very strong and inexpensive, and will be found most useful where several span-roofed structures are erected side by side (see p. 14).

The Ridge.—This is a stout plank employed to butt the upper ends of the rafters or sashbars against, in order to separate and keep them at their proper distance. A good average size for a ridge-plank is 7in. by $1\frac{1}{4}$in. or $1\frac{1}{2}$in.; in quite small structures a somewhat slighter piece may be employed, and for houses of 20ft. or more in width a heavier ridge, of say 8in. or 9in. by $1\frac{1}{2}$in. or $1\frac{3}{4}$in. stuff is better. A square groove, about $\frac{3}{8}$in. wide and $\frac{1}{4}$in. deep should be run along both sides to take the upper edges of the glass (see Fig. 45); but where the roof is composed of framed lights, or sashes, no groove is necessary. In the ridge-plank for a lean-to structure, a groove should be run on one side only. This (plank) is usually secured to the wall by means of stout nails, driven into wooden plugs in the brickwork, or with holdfasts. The groove should be run about halfway up the plank, or rather less, as shown, but, in any case, there must be width enough *above* the bars (rafters) to permit of the ventilators being properly hung. If the ventilators are 2in. thick, there should be a clear $2\frac{1}{2}$in. of ridge above the top of the rafters, and if the pitch is at all steep, 3in. will be better. The groove, which must, of course, be filled with putty before putting the glass in, may be dispensed with by tacking a short length of beading, or fillet, in between the bars, to support the upper edge of the squares, these being well bedded in putty, trimmed off and painted ; but this plan is only a makeshift.

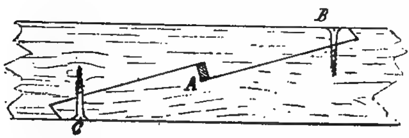


FIG. 46.

The lengths of ridging are joined together by scarfing the ends, as shown in the accompanying sketch (Fig. 46). In this, A is a wooden wedge, driven in to tighten up the joint, and cut off flush on each side afterwards ; a couple of long nails or screws at B and C make the joint complete. Such a joint in a 7in. plank should be 15in. to 18in. long.

Capping.—This is a length of wood worked to the sectional form shown in Fig. 47, and fixed on the top of the ridge-plank, as shown. Its use is partly to protect the ridge from the weather and partly to prevent any drip from entering along either side of the ridge, or along the top of the ventilators. When these are hung directly to the ridge, the capping is quite effectual for this purpose, but where a hanging piece is employed the joint comes just outside the capping, and in such cases it should be covered with a strip of thin canvas or stout calico, well tacked down top and bottom, and painted two coats.

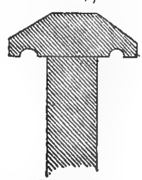


FIG. 47.

Purline.—This is a stout horizontal bar, or piece of quartering, fixed along crosswise of the rafters and about half-way between the ridge and wall or eave-plates.

It serves the double purpose of keeping the bars or rafters equi-distant and in their proper places in the middle, and also of supporting them at this point, and preventing any "sagging" of the roof from the weight of the glass, wind, or snow. A purline should always be supported at intervals of a few feet—6ft. to 10ft., according to circumstances—by means of "standards" of wood or iron. A purline increases the strength of the roof considerably, especially when the pitch is comparatively low. With a purline fixed half-way up, a 3in. by $1\frac{1}{2}$in. sashbar will carry a roof up to 10ft. or even 12ft. of rafter capitally, even with 21oz. glass, except, perhaps, in very exposed or windy places, when the 3in. by 2in. bars would be better and safer, particularly if wide squares of glass are employed—say over 15in. A portion of purline, with standards, fixed, is shown in Fig. 48.

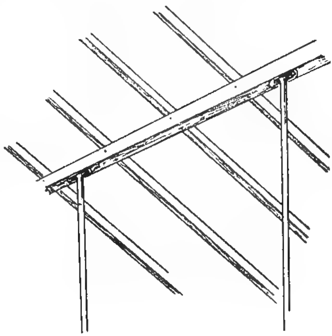


FIG. 48.

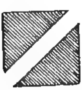


FIG. 49.

Where principal rafters are employed, no purlines are required, unless the rafters are very long indeed, though short iron bars are usually fixed between the principals, just to take the weight of the slighter bars. For this purpose, lengths of angle-iron are very suitable, making a very strong and neat job; a hole should be drilled opposite each sashbar, and a screw put in. In narrow houses, with rafters of 7ft. or less in length, no purlines are necessary, that is, if the bars are of not less than 3in. by $1\frac{1}{2}$in. stuff.

The neatest and best of all materials for a purline is $1\frac{1}{4}$in. or $1\frac{1}{2}$in. angle-iron, with a hole drilled opposite each rafter, and a $1\frac{1}{4}$in. screw put in. This obstructs scarcely any light, and is at once neat and very strong. It may be supported by means of either wooden or iron standards, but the latter are preferable, as being lighter and more durable. The only objection to this form of purline is the extra cost, which is much more than that of wood.

Lengths of 3in. by 3in. quartering, ripped down diagonally (or corner-wise), as shown in Fig. 49, are frequently employed. These are easily nailed to the bars, top and bottom, and present a flat, or nearly flat, surface below to take the top of the standard. But, though more troublesome to fix, having to be "skew nailed" to the rafters, ordinary 3in. by 2in. quartering (planed, of course), is somewhat better on the whole, obstructing less light, and being more easily jointed or halved together. In this case, if wooden standards are employed—these should be of 3in. by 3in. stuff, or 4in. by 3in., for large structures—they need only be notched, or "bird's mouthed," as a carpenter would say, at the top, to receive the purline. Standards made of $1\frac{1}{4}$in. or $1\frac{1}{2}$in. gas-barrel are frequently employed, and are both neat and strong. These had better have a thread run on each end, and a plain collar screwed on the bottom, to be built into a brick pier at the bottom, or fixed on a bed of concrete, with another collar drilled with three or four holes to screw it to the purline on the top. The lengths of piping

FIG. 50.

are, however, sometimes split down 3in. or 4in. at each end, and the halves bent and hammered out flat, a hole or two being drilled or punched for screws in each of the top arms, as shown in Fig. 50. But this is a somewhat clumsy method, and cannot be recommended foı first-class work.

Whether iron or wooden standards are used, the lower ends must be sunk a foot or more in the ground, and firmly fixed in a mass of concrete or brickwork, as shown in Fig. 31.

Besides acting as supports to the roof, standards are often very useful for supporting shelves, to assist in carrying staging, and for tying in the wall-plates, as well as helping to keep the house in shape, as shown in the sketch.

In wide houses, if the pathways come awkwardly and prevent the standards being placed so as to carry the purline in its proper position—along the middle of the rafters—the difficulty may be overcome by using levers, or by placing the standards in a sloping position, as in Fig. 31. When this is done, the standards take the inward thrust of the roof from wind, etc., better, but do not aid to keep the structure upright as the vertical ones do.

In Fig. 38, the different methods of tying the roof of a greenhouse of any kind or size together, are shown. The ordinary tie-bar, if iron, should be bent downwards to the proper angle, as shown in the sketch, and two or three holes for screws be drilled in each end.

The spandril, at least when employed alone, is only applicable to structures of comparatively small size, but the others may be employed in houses of any dimensions.

In large structures, where the roof is very wide and heavy, standards are sometimes placed to support the ridge at intervals, as this has a tendency to come down a little at the joints, but these are seldom necessary if the structure is properly tied together in other ways. Where the rafters are long, and great depth is inadmissable, the principals may be considerably strengthened by an arrangement of tie-rods as shown in Fig. 51.

It will be plainly seen that if the plates are so secured that they cannot bulge or give in the least, the ridge cannot possibly "come down," and consequently requires no extra support. Where several span-roofed houses are built side by side, yet separately, with side-glass and ventilators, it

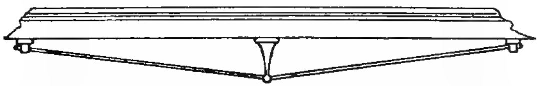


FIG. 51.

is a good plan to fix a stout iron bar, with a T or cross-head and a couple of screw-holes at each end, at intervals between the upper plates of each pair, as shown in Fig. 4. This fixes them securely at the right distance, and prevents any bulging absolutely.

Ventilators.—These, whether for the roof or sides, are made in exactly the same manner as an ordinary frame-light or sash, each consisting of a pair of styles, rebated on the inner edges to take the glass, and a top and bottom rail, each with a tenon cut on both ends to fit into corresponding mortices in the styles. They may, however, be made of any (rectangular) form and size, and are filled in with one or more lengths of slight sashbar stuff running parallel with the styles, according to the width of the glass and the number of widths in the ventilator. The top rail should be the same thickness as the styles—these ought to be cut from 2in. stuff in all cases, though in cheap work that $1\frac{1}{2}$in. in thickness only is frequently employed—and is also rebated on the inner or lower edge, for the glass, though a groove is sometimes run along instead. The bottom rail is, however, made wider—4in. to 6in.—and is only the thickness of the styles *less* the depth of the rebate—that is, its upper surface, on which the glass rests, is made flush with the rebate in the styles and the top rail. The smaller bars are mortised into the top rail about an inch, and the lower ends just let into the bottom one for about half an inch, a "tail" of the upper portion (above the rebate) $1\frac{1}{2}$in. or 2in. long, being left and tacked down to the face of the lower rail, as shown in Fig. 52.

FIG. 52.

A common form of ventilator is that of an oblong, or nearly twice as wide (along the rails) as deep. A ventilator with the styles and top rail made out of 3in. by 2in. stuff, and about 54in. long by 24in. or 25in. deep, will just take three squares of 20in. by 16in. glass, and will cover *four* $1\frac{1}{2}$in. bars at the same distance (16in.), or *three* spaces, nicely, with an overlap of about 1in. at each end, which is just right. A ventilator should overhang the seat by 1in. or $1\frac{1}{2}$in. at the bottom. A small groove is sometimes ploughed along each side of such ventilators, about $\frac{1}{2}$in. from the edge, and on the under side. This is intended to prevent any drip driving in between the styles and the bars of the roof in stormy weather, but it is scarcely necessary.

Roof-ventilators of the usual type (see p. 33) are almost invariably hung either directly to the ridge-plank, or else to a "hanging piece" fixed to it (see Fig. 31), by means of hinges of some kind. The ordinary "butt" hinges are however very unsuitable, as, if unused for a time, they soon rust together and stick, with exposure to the weather, and when the ventilators are opened again, become wrenched off. What are termed "water joints" are better, but not sufficiently exact for anything but very rough work. What are termed cross-garnets are more suitable, but even these "stick" sometimes, and they are decidedly inferior to Paine's patent joints, or hinges. These are made in pairs, right and left, in malleable cast-iron, and while working very truly they cannot possibly hang or stick; they also aid in keeping the framework of the ventilator together (see Fig. 53), and, lastly, they are very inexpensive. Piper's patent hinge is a still stronger and better-finished article, very suitable for first-rate work, but naturally more costly than the last.

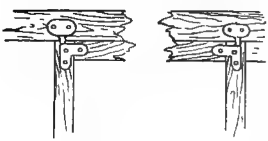


FIG. 53.

A point gained by dispensing with hanging-pieces, and hanging the ventilators directly on to the ridge (in this case their upper edges must, of course, be bevelled, or champfered, to the proper angle), is that the joint is brought under the capping (where this is used), and any "drip" at this point thus prevented. A hanging-piece is, however, more easily fitted closely to the ridge, and if its lower edge, as well as that of the ventilator, is planed quite true, the joint will be so close as to be almost, if not quite, watertight. Care must, however, be taken in all cases not to hang ventilators so tightly that they cannot "sit down" easily and well, or so that they "gape" at the bottom when closed. In fact, great care ought always to be bestowed on the proper hanging of ventilators, as unless they fit closely

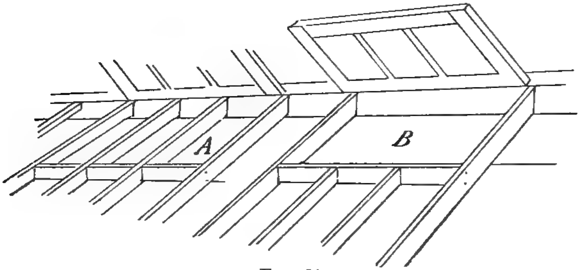


FIG. 54.

at all points, there will be a considerable loss of heat in windy weather, to say nothing of the inconvenience and damage caused by drip.

Before proceeding to consider the ventilator seats, another point of some importance must be dealt with. This is whether the bars should be carried through to the ridge beneath the ventilators or not (see A and B, Fig. 54).

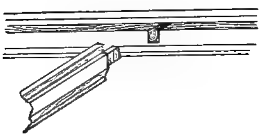


FIG. 55.

The latter plan has the neater and better appearance, and in this case the ventilator seat can be put in in one piece, and a close fit is thus more easily made between the two. If this method is adopted, a tenon should be cut on the end of each *short* bar (see Fig. 55), to fit into a corresponding mortice in the seat. The seat should be made of fairly stout stuff, 1½in. or 2in. thick, and rebated or grooved on the lower side to take the upper edges of the glass; though, failing this, a fillet, or bit of beading, tacked on will answer nearly as well.

When the ventilators are placed opposite each other along the ridge of a span-roofed, or three-quarter-span, house, or in the case of a lean-to structure, the plan just described is an excellent one, and may be safely adopted, provided that the ventilators are not very long. But when they are placed *alternately* on each side of the ridge, according to the usual and proper practice, this objection to the plan of cutting the ends of the bars off beneath the ventilators occurs—that the thrust of the bars or rafters on the opposite side of the ridge-plank forces the latter, unless a very heavy one, slightly out of line, and then the ventilators, or the hanging-pieces, do not fit well, gaping at each end, unless hollowed a little in the middle. It is, consequently, better to carry the bars right through to the ridge, certainly where the usual three-square ventilators are employed, fitting short lengths of "seat" in between the bars, and thus ensuring a straight ridge. With continuous ventilators it will usually suffice to carry every alternate or third bar through; though these should be *opposite* each other on each side, and where principal rafters are used these only need be of the full length, with a stout seat to carry the ends of the smaller bars safely.

Glazed side- or front-ventilators are framed together in exactly the same manner as those in the roof, with two styles, a top rail of the same thickness, and a thinner and wider one at the bottom, and two, three, or more light sashbars disposed equidistantly between. In conservatories and other large structures the side-lights are usually of considerable depth—from 3ft. to 5ft., or more—and, as a rule, the majority are fixed, only one here and there being hung; but for the best class of houses for "growing" purposes, the system of low roofs and side lights—all "hung" so as to be opened at will—is decidedly preferable.

The Ends.—In constructing the ends of a house, the usual way is to fix a proper "plate" (see Fig. 35, p. 52) level with either the lower (or wall) plate, or sometimes with the upper (or eaves) plate, if there is one,

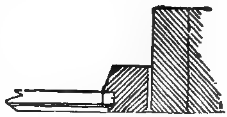


FIG. 56.

and then to fill in the rest of the space with light vertical bars, cut to the angle of the end rafters at the top, and tacked in top and bottom. If there is a door, however, what is called a transom is put in (see Fig. 31, p. 50) at the same height as the lintel would come; or if this is high enough, level with the upper plates of the house. But as the transom, which is really a lintel carried right through to the outside timbers at each end, usually comes above even the upper plates, the ends have to be cut to the proper angle and secured to the end rafters by means of nails, or, if possible, a shoulder or "return" should be left and nailed on inside as well. In lofty houses it is usual to put in a transom, or even two, in the ends, whether there are any doors or not (see Figs. 56 and 57).

FIG. 57.

Unless rebated on the top—which is not advisable, as a rule—short lengths of beading, or fillet, should be tacked in between the ends of the bars, on the transom (end-plates are always rebated), to take the lower edges of the glass, and the same thing may be done below, or a groove may be run along instead. The lower ends of the (vertical) bars may be let (mortised) $\frac{1}{2}$in. or $\frac{3}{4}$in. into the transom and wall-plate; but if this is done the tenons ought to fit very tightly, and the holes have a good dab of thick white (lead) paint, so as to prevent any soakage of water into the wood. Another way is to tack a strip of beading all along (if there is no rebate) first, then cut the ends of the bars with shoulders, and simply skew-nail each in its place. This may be done at both top and bottom.

It is an excellent plan to champfer off the upper surface of a transom, on the inside, in order to prevent any lodgment of water, though this is seldom done.

Where there is no door, the end of a comparatively low structure is simply filled in with light bars, fixed vertically at the right distances, as above. The 2in. by $1\frac{1}{4}$in. is a useful size of bar for such work. In the absence of a door, a large hanging ventilator is frequently placed in the end of a span-roofed house.

Remember, when nailing in the bars, whether in the roof or ends, that it is impossible to be too careful in fixing them at exactly the right distance apart. If too "tight," great difficulty will be experienced in getting the sheets of glass in place, especially as one or two, a shade wider than the rest, are sure to be found here and there—this it is almost impossible to avoid—and if the bars are fixed at the bare width of the glass apart, there will probably be a lot of troublesome cutting to do, as well as great difficulty experienced in getting most of the glass in at all. If, on the other hand, the bars are put in too "wide" there will be too much play, and some of the squares will drop through altogether, causing a lot of extra trouble, and altogether preventing anything like sound work being made.

I always allow a bare $\frac{1}{16}$in. "play" only, and find this answers admirably. The gauge should always be used again when nailing or screwing the bars to the purline, or *vice versa*, and take care that the former are fixed straight.

Houses of any considerable size ought always to be fitted with gearing of some kind, to avoid the immense amount of time otherwise occupied in opening and closing the numerous ventilators. Several descriptions of gearing are now manufactured, but at once the simplest, most easily worked, and best, is Paine's Counterbalance gearing, which is, moreover, by no means *expensive.* With this all the ventilators in one row are opened and closed simultaneously by means of a length of ordinary $\frac{3}{4}$in. or 1in. gas barrel, firmly screwed together and working in proper cast brackets, or carriages, screwed to the rafters or uprights. On to this are firmly keyed the levers, each with its connecting rod, to actuate each ventilator, and at intervals other short levers, each carrying a heavy cast iron weight, are fixed in such a manner as to counterbalance the weight of the lights completely, and thus enable them to be opened or closed with the greatest ease. The rod is worked by means of a toothed wheel and worm, which may be placed at either end, or in the centre of a long house, and is actuated by means of a rod and hand wheel fixed in any convenient spot.

Gutters.—These are referred to now, because, in some cases, they enter in part into the construction of a house, or houses, as will be seen presently. Gutters of some kind ought always to be provided, for not only is a plentiful supply of rain-water at all times useful, but this, being perfectly pure, is invaluable in good plant-growing, especially for syringing, etc., as containing no mineral matters, it leaves no deposit or discolouration of the foliage. Again, where there are no gutters, the water from the roof is shot directly on the ground, rendering the soil sodden and soft in times of heavy rain, and often causing the foundations to become rotten and give way, and in the case of vineries rendering the borders sodden and sour.

The ordinary half-round guttering, about 4in. diameter, is usually employed for greenhouse work, and is fixed either by means of common brackets, or if there are piers built at intervals outside the wall, the gutter may be conveniently bedded on these. For houses built with side glass and two plates, the gutters must, of course, be fixed to the upper one, and in this case, the ogee or O.G. pattern is most suitable, as being at once more easily fixed (with long screws), and affording a neater appearance.

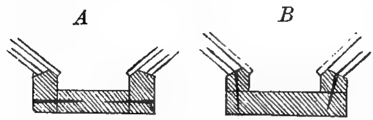


FIG. 58.

Low span-roofed houses built with a "drip" board along the eaves are easily provided with gutters by nailing a small neat batten at right angles to the drip, along its lower edge, as described on p. 58.

Gutters between two or more span-roofs, constructed contiguously (as in Fig. 5), should be wide enough for a man to walk along easily, that is to say, 7in. or 8in. in the clear, or more if convenient. Such gutters may be constructed in either of the ways shown at A, and B in Fig. 58, and should either have a good coat, or two, of tar or pitch, or better still, be lined with lead. Cast-iron gutters are now made for this and similar purposes, and are at once strong, useful, lasting, and comparatively inexpensive.

CHAPTER V.

GLASS AND GLAZING, PAINTING, ETC.

The abolition of the duty on glass, and the consequent reduction in its cost, gave an enormous impetus to indoor horticulture generally, and to a great extent accounts for the marvellously low present prices of forced fruit, flowers, and glass-house produce in general. While the duty remained in force, a greenhouse was a luxury only within reach of the rich, but now even the careful and industrious working man can indulge his hobby for cultivating tomatoes or choice flowers to a moderate extent, while the total amount of glass employed in the horticultural market trade throughout the country is really enormous.

The foreign (Belgian) glass is even cheaper than the commonest description of English make, but at the same time it is decidedly inferior in both quality and colour, and where a little extra expense is no object, a fairly good quality of English glass should be employed. The foreign glass is usually distinguished by an extreme hardness and brittleness, as well as by a decided bluish or greenish hue, which is most noticeable when viewed edgewise of the sheets. It is also too often full of "feathers," "waves," and other imperfections, which are held by some growers to "draw" the sunlight, and thus have a very unfavourable effect upon the plants growing beneath. The foreign glass is also, from its hardness, more or less difficult to cut, and very liable to "fly," while good English glass is nearly white in colour, cuts "soft" to the diamond, and yet is tough and does not readily crack or fly. Some makes or "brands" of the Belgian glass are considerably superior to others, but none are equal to good English material in softness, toughness, and transparency. Clear glass naturally admits more light than inferior qualities, and in winter practically every ray is of importance to the growth of plants. Glass full of "shakes" and "feathers" should be avoided, as it draws or distorts the light sadly—indeed, it has been affirmed that such glass is one cause of the troublesome tomato disease known as the "droops" or "falls."

Good Belgian glass (21oz.) can now be purchased, already cut to size, for about 10s. per 100 square feet, and if a large quantity is required at an even lower rate, while English glass of sufficiently fine quality for horticultural purposes costs very little more.

What is known as 21oz. glass only ought to be used in the construction of glass-houses of any kind, the 15oz. being poor thin stuff, unable to resist hail or even high winds, and constantly cracking and failing. In small squares it may be employed for cheap frames, small pits, etc.; but even then it should be carefully selected.

Except for such small frame-lights, etc., the very small squares of glass, often only 6in. by 4in. or less, that were so largely employed many years ago, are seldom seen and never used at the present day. Houses so constructed, with a maximum of woodwork and a minimum of glass, are totally unfit for the growth of tropical or exotic plants, which, when grown under such conditions, are always more or less long-legged, weak, and spindly. Then the numerous and too often unnecessarily wide "laps" still further exclude the light, especially when they become clogged with dirt and slime, and beyond this they admit an enormous quantity of the outside air, in windy weather especially, thus involving the waste of a large amount of heat, and rendering it impossible to maintain a close atmosphere, or any amount of atmospheric moisture in the structure. Houses of this kind require little or no ventilation—the outer air gains ingress and egress quite fast enough without it!

The modern builder constructs the framework of his houses as lightly as possible, with comparatively few and thin, if somewhat deep, bars or rafters, and wide squares of glass. A very good and useful size for the latter is 20in. by 16in., but for small structures the 20in. by 15in. size will answer quite as well. Very large and wide structures, such as vineries, etc., may be advantageously constructed with glass as wide as 18in., or even 20in.—the 24in. by 18in. is now kept as a stock size by most glass merchants—and at least one of the large London market growers of pot plants, etc., builds all his houses with glass no less than 24in. in width.

It is, however, a great error, whether done with a view of economising the woodwork, or with any other object, to put the glass in transversely of the bars—that is, with the longer sides of each square *across* the bars instead of parallel with them. When this is done, the squares are very liable to crack across the middle, and then they are sure to drip, and may drop out altogether. In all cases, fix the glass with its longest measurements the same way as the bars or rafters. Very long pieces of glass, again, frequently crack across, even when put in properly, especially as they are seldom quite straight (flat), and on the whole such proportions as 20in. by 15in. or 16in., 24in. by 18in., 15in. by 10in., etc., cannot easily be improved upon.

When commencing to glaze a house, always begin at the bottom of the roof, and work upwards, rank by rank. Drive a couple of stout tacks, or short wire nails, in the "drip" to keep the first square from slipping down, and to each of the others use three or four tacks or brads for a small square, or five or six to each large one.

FIG. 59.

Shoemakers' rivets are the best to use, the $\frac{5}{8}$ths being a very useful size ; the brass rivets are superior to iron ones, as they do not rust, but they are, of course, rather more expensive. In default of a proper glazing hammer (see Fig. 59), the side of an old chisel makes a capital substitute. The two bottom brads, one on each side, must be driven in *on* the lap, and not above it, or the glass will probably "fly" across the corner. Drive a brad in on one or both sides half-an-inch from the top of each square, for the lower edge of the next one to rest on. This gives quite enough lap ; more is unnecessary, and only obstructs the light when it gets clogged with dirt or slime.

Of course, the putty must go in first. Use only the best, made of boiled linseed oil and whitening only, and work it till quite soft and smooth. By far the best method of glazing is to bed the glass in well, using plenty of putty, and pressing the edges of the glass down firmly, and when in and tacked, trim off the putty smoothly, both inside and out, filling up any cracks. Then when painting, let the side of the tool (brush) just catch the edge of the glass all along ; a roof thus glazed will not leak a drop, and require no care or attention, beyond an occasional coat of paint, for many years. Top putty is an endless nuisance and source of "drip" ; under the heat of the summer sun it cracks and comes off wholesale, and then has, of course, to be replaced. The late Duke of Marlborough is said to have complained with reference to his numerous Orchid and other houses that he "had to spend six hundred a year in putty," and though this may seem incredible, yet the annual renewal of "top putty" in an extensive range of houses, including the necessary labour and painting as well as material would soon run into three figures. By adopting the method recommended above, the noble Duke might easily have reduced the above amount by at least three-fourths.

Always put the glass in with the concave side up—convex side *down.* Though apparently a small matter, this makes a great deal of difference in the "tightness" or otherwise of a roof, as the squares "sit down" very much closer and better in this way than any other, while the water is thus conducted to a great extent away from the bars. A truly flat square of glass, or one perfectly true at the edges, is very seldom met with.

When glazing the ends of a house, upright side-lights, or doors, etc., the ends of the squares of glass are sometimes merely butted together, without any laps. In this way, less tacking is required, and the glass cannot possibly slip, but unless the edges are cut very true a good deal of air may be admitted where the squares meet. For best work the glass should all be lapped, and well tacked in ; a couple of brads must be put in underneath each square, one on each side, so as to support it firmly, and prevent any slipping. All lights, etc., are, however, usually glazed on the flat, so that only the ends of a house have to be filled in upright.

Only the best white lead paint ought ever to be used for greenhouse work, and to keep the houses in good condition a fresh coat ought to be given every year, or every second year at farthest. A very usual method, and one frequently stipulated for in building by contract, is to give "two coats down and one up"—*i.e.*, two coats before erection and one afterwards. Personally, I would as soon glaze on one coat of paint as on two, and put the extra one on after, but two thin coats of priming are better than one thick one, and thorough priming is an important point. Red and white lead mixed is usually employed for priming, and nothing but the best (boiled) linseed oil, with a moderate quantity of "turps," and a little patent driers, should be used in mixing all paints. Always mix thoroughly, taking plenty of time over the job, and strain before use. Of course, neither outside painting nor glazing ought ever to be done unless the bars and other woodwork are perfectly dry, in fact, neither *can* be performed properly when the wood is in the least damp. For the later coats, white is usually put on, but as the pure colour does not look well, and very soon becomes soiled, it is usually toned down with a little umber, grey lead colour, or blue—just enough to "take the raw edge off."

When putting on the last coat, or coats, a little care and taste in the choice of tints is by no means thrown away, certainly where an ornamental appearance is aimed at. A very good plan is to use a nice soft white—a French, or paper white—for the bulk of the woodwork (inside), and "pick out" the tie-rods, standards and other ironwork with dark or light blue, or a pale sea-green looks very well and affords a little variety.

The best time for all outside painting is in the early autumn, when, drying more slowly and sinking in better, it sets harder and lasts longer than if put on earlier. Painting done in the spring or summer dries quickly under the hot sunshine, and even if it does not crack or peel off, perishes much more quickly than that done in the autumn.

Never use tar, or the so-called "black varnish," which consists of the same thing to a great extent, inside a plant house of any kind, for any purpose. Both give off a horrible smell, when the place gets warm, for some time, and the fumes have a most destructive effect upon plants of all kinds. Beyond this, wherever oil paint touches a bit of tar it turns to a dirty brown or drab hue. A little tar is only admissible in the case of wooden gutters, etc., outside the house.

Iron.—Iron is now employed to a considerable extent in the construction of greenhouses, though by many it is objected to on account of its greater conductive power rendering the loss of heat considerable as compared with wood.

Its superior lightness and strength are, however, important advantages, and it is doubtful whether the objection mentioned above is not more theoretical than practical. The area of bars, etc., presented to either the inner or outer surface, and through which alone the heat can be diffused, is comparatively insignificant, while the depth, or thickness, is per force considerable. Still, the theory is perfectly valid, and must be taken into consideration, especially in the case of stoves and forcing houses, etc., in which a temperature considerably above that of the outer air has to be maintained.

Lengths of ordinary T iron may be easily substituted for the usual wooden rafters, or sash-bars, the glass being, of course, bedded in with putty, in the usual way (see Fig. 60). The difficulty lies, however, in finding a suitable method of fastening the squares down, tacks or brads being inadmissible, of course. Holes may, however, be drilled through the flange or rib of the bars, opposite the lower end of each square, a pin being inserted in each hole, and the glass secured by means of small wedges or cams; or small saddle-shaped spring clips, each with a screw on one side, may be employed, but the ends of these should be shod with leather or rubber, to avoid any risk of fracturing the glass. Or the glass may be easily fixed by means of lead clips encircling the lower part or "flat" of the bars, which are, of course, inverted thus—⊥.

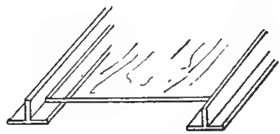


FIG. 60.

One large nurseryman in the north of London constructs most of his houses with T iron bars, in a very similar manner to that described above. The walls are of concrete, the ends of the bars being bent as shown in the accompanying sketch (Fig. 61), and bedded firmly in the concrete. The upper ends of the bars, or rafters, are kept at the proper distances by means of an ordinary ridge plank, into which the bars are let slightly, and the glass, which is 24 inches wide, is bedded in putty and secured by means of clips.

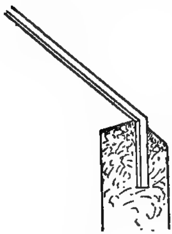


FIG. 61.

Another method of glazing with iron bars is shown in Fig. 62. Here the bars are formed of angle-iron ($1\frac{1}{4}$in. to $1\frac{1}{2}$in.), and run horizontally, as shown in the sketch, being supported by stout vertical rafters of 4in. by 3in. or 5in. by 3in. stuff, into which the lower flange is let, or to avoid weakening the rafters, the pieces may be cut out at the proper points. In either case the flat side is secured to the rafter by a stout screw. The glass, which must be in tolerably large squares, and be cut perfectly true at the edges (these being simply butted together), is fastened by means of  shaped clips of stout zinc, as shown at B in the sketch. This makes a nice light house, suitable for pelargoniums and other plants that require free ventilation and abundant light, and as no putty is required, the glass is very quickly

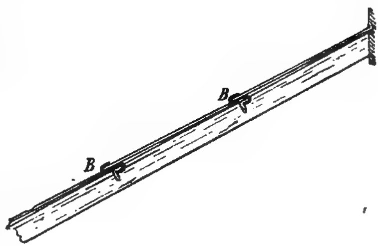


FIG. 62.

put in, but the objections are, that however carefully fixed, the glass "chatters" badly in windy weather, and at such times there is also a considerable loss of heat.

There are also many other methods of "glazing without putty," the glass being carried in bars of iron, lead, or zinc, one of the best being what is known as the "simplex lead glazing," shown in Fig. 63. This system was introduced by Messrs. Grover & Son, of Wharf Road, City Road (London), and forms a simple and excellent means of securing glass to bars of almost any kind. Where bars of T iron are employed, as above, the simplex lead glazing is

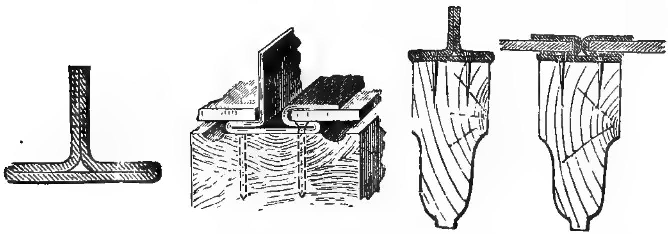


FIG. 63.

much the best method of fixing the glass. But most, if not all the other systems are open to serious objections of some kind, and after all there is nothing superior, if equal, for most purposes, to the old fashioned method of wooden bars and glass well bedded in putty, but without any top-putty, as already described.

Iron uprights, or "muntins," are also frequently employed in the construction of houses with side or front sashes, to carry the upper plates. Being at once light and strong these are very useful, and if desired may be made so as to be built into the brickwork, or concrete, though as a rule they are cast simply with shoes at the base to fit on to and be secured to the bottom plate with screws or bolts. They may also be cast with lugs on the upper ends to which brackets to carry the lower ends of the rafters may be bolted, or simply with shoes cast on, to receive the latter. Lugs are also frequently cast on them to which the ends of the T irons which carry the wires in vineries and cucumber houses may be bolted.

Cast-iron spandrils are frequently employed in the construction of span-roofs, whether principal rafters are used or not. These not only secure the rafters at the proper angle, but have a very light and ornamental appearance also; if sufficiently large, they, to a great extent, dispense with the necessity for tie-rods across the roof, unless the rafters are of great length, and lastly, they afford more head-room in small structures than if tie-rods were employed (see Fig. 64). At the same time these last, if made of stout bar-iron, are very useful to carry shelves upon, where there is enough head-room beneath to move about comfortably.

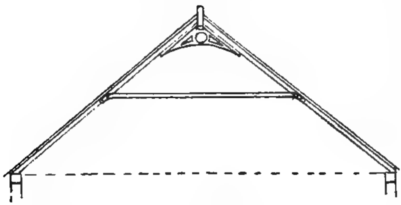


FIG. 64:

Standards should always consist of iron, if possible, as wooden ones have a very heavy appearance. In nurserymen's structures they frequently consist simply of a length of ordinary $1\frac{1}{4}$in. or $1\frac{1}{2}$in. gas-barrel, but in large conservatories, palm-houses, etc., cast-iron columns are employed to support the roof.

CHAPTER VI.

STAGING, BEDS, ETC.

THE interior of a plant-house of any kind may be arranged in several different ways, as regards the disposition of the beds, stages, etc. The simplest method of arrangement for a plain span-roofed structure of 9ft. or 10ft. up to 12ft. or 14ft. in width is to have a central pathway 2½ft. or 3ft. wide, and two solid raised beds, one on each side, as shown in Fig. 100. This arrangement suits such plants as ordinary "geraniums," fuchsias, cinerarias, primulas, etc., etc., with the usual run of "bedding plants," admirably, whether the house is provided with side-ventilators or not, but the large-flowering pelargoniums, begonias (when grown in a cold house), and a few other things, thrive best on an open or lattice staging, where a current of air is always passing up through the plants. For such plants, a raised staging constructed as shown in Fig. 65 should be provided.

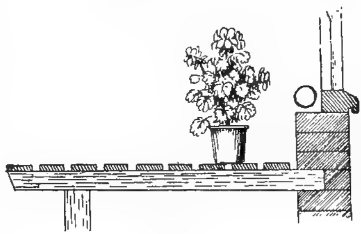


FIG. 65.

A large quantity of material of some kind—such as ashes, clinkers, brick-rubbish, clay, or the like—is, however, required to make the solid beds referred to above, unless of course, the house is partly sunk, when the soil taken out of the pathway will go a good way towards it. But except for bedding plants, etc., such sunk houses are not now considered desirable, so that unless there is plenty of rough materials of some kind at hand it becomes necessary to employ raised stages. Solid beds must be surfaced with 3in. or 4in. of moderately fine ashes, to prevent worms entering the pots. Most pot plants thrive better on such a solid ash-bed than elsewhere, especially in hot weather, when the cool, moist bottom is very grateful to the plants. Pots standing on an open or lath staging directly over two or more rows of hot pipes also become dry very quickly, and unless frequently attended to with water, are very liable to suffer from extreme drought. In nearly all such cases the staging should be a close or impervious one, especially if the pipes are at all near the staging.

Raised stagings may be constructed in several ways, and of various materials. The old-fashioned style was to use narrow battens, or stout laths, about 2in. by 1in. in section, nailed down to wooden joists let into the wall at the back, and supported by a post or upright, also of wood, in front. A space of nearly an inch was allowed between each pair of battens, in order to allow of any surplus water passing freely away from the pots, and also of a free current of air passing between the plants. As already seen, this plan suits pelargoniums and some other plants growing in a cool temperature, but when there are hot water pipes immediately beneath, the pots are liable to suffer seriously from drought.

In many market nurseries the stages are constructed simply of ordinary flooring boards, 5in. or 6in. wide, laid on and lightly nailed to rough wooden uprights and cross-bearers, a space of ½in. or ¾in. being allowed between each. This answers well—better on the whole than the narrow batten or lath staging, but with the objection that after a few years' use the wood decays, and has to be replaced. If well painted before use, the wood naturally lasts much longer, but such preservatives as

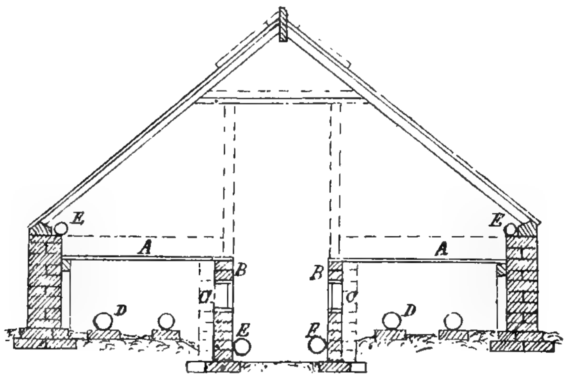
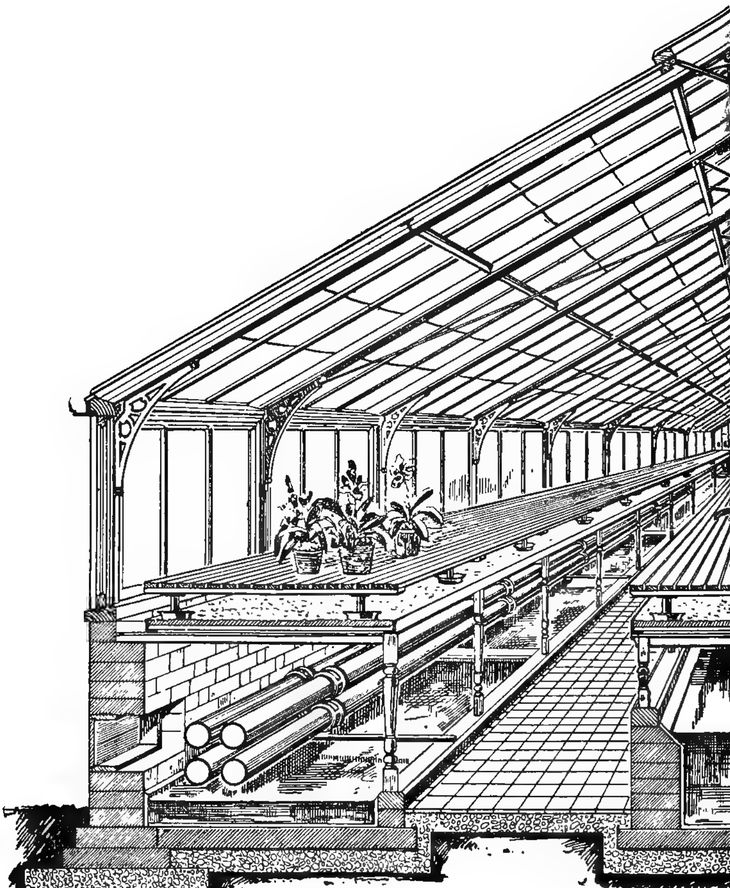
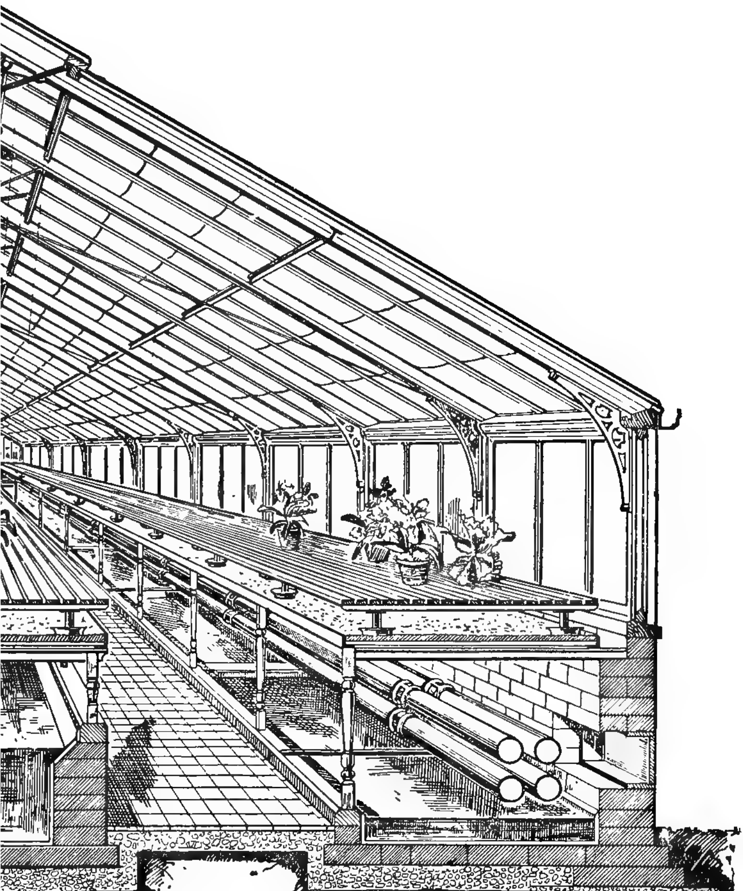


FIG. 66.

tar, creosote, and the "black varnish" are inadmissible in the interior of plant houses, as already stated.

Slate forms an admirable material for the surface of staging, being perfectly clean and sweet, as well as semi-porous, and a fair, but not too rapid, conductor of heat. Slate slabs of sufficient thickness to sustain the weight of a number of pots (which, when full of moist earth, weigh more than many would credit), with that of a man occasionally, are, however, somewhat costly





and though fairly stout roofing-slates may be employed, these must be supported by battens or narrow boards laid rather closely beneath them, to prevent their giving way beneath the weight.

Houses for the growth of ferns and similar plants are sometimes constructed with a slate staging, as shown in Fig. 66, where A is the slate bed, B a low 4½in. wall run up along both sides of the central pathway to carry the cross timbers (or lengths of T iron), with openings C, placed 3ft. or 4ft. apart, to allow some of the heat to escape into the house, and D D the pipes. By fitting the openings C C (which may be 18in. by 6in. or 9in. each) with sliding or hinged wooden flaps or doors, the heat may be confined beneath the staging, and a kind of gentle hot-bed thus secured, but in this case top heat should be provided by means of a few rows of 2in. or 3in. piping, as at E E in the sketch.

The galvanized (or more correctly zinc-coated) corrugated iron which is now so extensively used and sold so cheaply, in sheets about 2ft. wide and from 5ft. to 10ft. long, forms one of the very best materials for staging, and is now largely employed for this purpose. It is at once light, strong, lasting, and a good conductor, as well as being very inexpensive. It must, of course, be surfaced with 2in. or so of fine gravel, beach shingle, or "ballast" (clay burnt in the rough), on which to stand the pots. Ashes must not be used, as they quickly corrode the metal, and each sheet ought, in any case, to have a coat of thick, hot, lime-wash before being used. The sheets may be laid on cross-bearers of wood, T or angle-iron, or ordinary gas-barrel, placed not more than 18in. apart, and a 3in. or 4in. by

1in. batten should be fixed on edge along the front, to prevent the shingle or whatever is used falling about. This iron staging is very suitable for use in stoves and forcing houses, where several rows of pipes run beneath, and water is used in large quantities. Iron supports are of course more expensive than wooden ones, but at the same time they are much more lasting, especially if kept properly painted.

The step, or ladder, stages so frequently seen in old-fashioned houses are seldom used now, and scarcely ever by trade or market growers. They are ugly, clumsy contrivances at the best, exhibiting more of the sides of the pots than anything else, and are only allowable in lofty structures, where the plants would otherwise be too far from the glass. In wide plant-houses where there are two pathways and a centre staging, a kind of double ladder or pyramidal staging is sometimes adopted for the latter, and is very useful where large specimen begonias, orchids, or the like are grown. I have several times employed such stages, constructed in three tiers, and chiefly of flooring boards, with good effect. The centre shelf ought to be wider than the others, and neither of the tiers should be elevated too much. As a rule, however, nurserymen prefer flat, or level, and rather low stages to any other form, where the plants can all stand on the same level, and be easily accessible for watering, etc., as well as below the eye, and therefore more effective. In Fig. 67 an admirably designed structure intended for the culture of orchids is shown. This was built by Mr. Duncan Tucker, of Tottenham, to whom we are indebted for the engraving.

With very few exceptions, houses of most kinds, and those intended for the growth of pot plants in particular, of more than 14ft. or 15ft. in width, should be laid out with *two* pathways and *three* beds, or stages—a narrow one on each side, and a wider one in the centre—as shown in Figs. 14 and 68. Working among the numerous plants and attending to their various wants is thus rendered much easier than where the beds are very wide. Even a tall or long-armed man cannot conveniently reach more than about 4ft., and though, with a long-spouted can, one can water plants a little farther off still, yet it is impossible to see distinctly whether plants at the back of a very wide bed are dry or not, while the pots cannot be got at to be tapped either. Indeed, it may be taken as a rule that no bed or stage for pot plants ought to exceed 4ft. or 4½ft. at the most in width, unless of course there is a pathway on both sides of it, when it may be extended to 6ft. or even 8ft.

Even in the case of wide structures, planted with tomatoes, roses, or the like, it is much better to have two or three narrow paths running along them than to allow the plants to stand in wide blocks, where they will be liable to run up and become weak from lack of light and air, to say nothing of the difficulty of working among them, or gathering the fruit, properly.

Pathways may vary from 2ft. to 4ft. in width; 2ft. may be taken as the minimum, where space is an object, but 2½ft. is usually a much more convenient width, even in structures intended for growing purposes only, and a width of 3ft. is usually sufficient for conservatories and show houses.

A convenient height for raised beds and stages for plants in pots, etc., is from 2ft. to 2½ft.; the former are usually made somewhat lower than the latter. Ash-beds for large or tall plants frequently do not exceed 18in. or so in height, but stages should be higher, 2½ft. being about right. In lofty houses very high stages are occasionally employed, in order to bring the plants up nearer the glass, but anything over 3ft. in height is exceedingly awkward, and even this height is rather inconvenient for any but a very tall man to work at.

It may be mentioned, in passing, that when mounds, or a ridge, of soil have to be put down on an ordinary wood

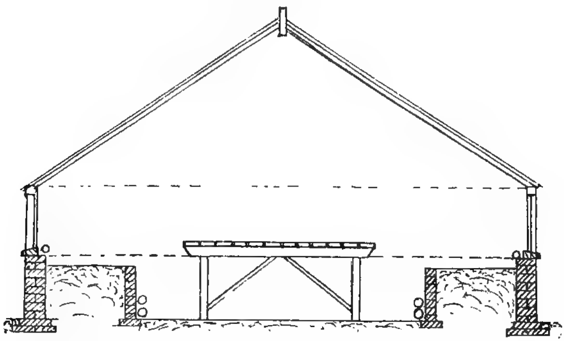


FIG. 68.

or other staging, according to a common practice in the culture of cucumbers and tomatoes, some ordinary or roofing slates ought to be laid down first; even where the staging is surfaced with iron this had better be done, as the roots dislike contact with this or any metal, while slate is very agreeable to them. Such ridges or mounds of soil may be kept in place by means of a few loose bricks.

Fig. 68 shows the section of a very well-arranged and useful structure for the culture of specimen or large plants of begonias, roses, bouvardias, carnations, or anything of the kind, in pots. The side beds, it will be seen, are solid, being filled up with ashes, rough soil, or the like, and are surfaced with ashes or sea-sand. This last, by the way, is a capital material for surfacing the beds or stages in plant houses, being at once perfectly sweet and porous, and a preventive of insects, while it also presents a smooth and, when moist, sufficiently firm surface. The middle of the house is shown fitted with a flat-topped raised staging, and if this is constructed of flooring boards or the like and trestle legs, held together by means of a few screws only, so as to be easily removable, it can be taken down in the autumn and the space rendered available for standing large chrysanthemums in pots, or the like. A low, solid bed may of course be substituted, if preferred, or the space planted with tomatoes during the summer. This type of house, but with low or level beds, is indeed admirably adapted for the growth of tomatoes on a large scale.

Shelves.—Shelves near the glass are extremely useful for certain purposes, such as for standing seed-pans, boxes, or small pots on, and they are frequently fitted in propagating and other houses. Being usually fixed close to the glass, any plants placed on them cannot become drawn, and make a very short and sturdy growth, but as soon as they become tall enough to touch the glass, or nearly so, when the tops are liable to suffer from frost outside, as well as from hot sun, they must of course be removed elsewhere.

Shelves are constructed, as a rule, of ordinary flooring boards, from 6in. to 9in. wide, and may be supported by means of iron or wooden brackets, or in any convenient manner. A very common position for shelves in the low span-roofed houses usually employed by market growers is on each side the central pathway, where, if there are standards here and there, they are easily supported by means of pieces of stout batten nailed across from the upper part of the standards to the inside of a rafter or sash-bar, as shown in the sketch (Fig. 70). Here they are not in the way, neither do they obstruct the light to any extent from the beds beneath, unless fixed very low, but as a rule the nearer they are to the glass the better, in reason, from 9in. to 12in. being a very suitable distance. In houses provided with strong cross-ties in the roof, whether of iron or wood, shelves are sometimes laid on these, over the central or side pathways, there also they do little or no harm, and accommodate a quantity of small stuff, but being overhead it is a rather troublesome matter to get at and water their contents.

Shelves slung to the rafters are, however, by no means to be recommended, being not only very unsafe, but increasing the strain where there is already quite enough weight to be carried. In three-quarter span-roofed and lean-to houses the best places for shelves are in front of the pathway, close to the tops of the standards, and at the back, against or near the back wall.

Shelves are sometimes fitted with a fillet tacked on both edges, and projecting ½in. or so above the upper surface on both sides—this is done to prevent the surplus water from the pots from dripping on to choice plants, etc., beneath, but in this case each should be given a gentle inclination towards one end; or a groove may be run along each side, ½in. from the edge, with the same object.

Tanks.—Tanks of some description are almost indispensable in all well-appointed plant houses. Their object is two-fold: firstly, to provide storage for the rain or other water, and secondly, to ensure its being of about the same temperature as the interior of the house itself. The use of very cold water, as that drawn direct from a well or cistern in the open air, is often very detrimental to the health and welfare of plants, especially of such as are being forced, or cultivated in a high temperature. By allowing it to stand in an inside tank for a day or two the chill is taken off it, and its temperature becomes nearly the same as that of the atmosphere.

Tanks may be constructed in various ways, and of various materials. At one time slate tanks were very much in vogue, and wooden ones, constructed of stout planks well bolted together, and lined with lead or zinc, or simply well tarred inside, are frequently employed, but it may be as well to state that zinc tanks should be avoided, as when rain-water has stood in this material for any length of time, it has a very deleterious effect upon pot and other plants, and many otherwise unaccountable failures have been traced to this cause. The rust from ordinary iron tanks is innocuous to plant life, unless applied frequently and in considerable quantities, when it has the effect of stunting the growth of most plants, though it intensifies the colour of most flowers. Galvanized iron cisterns (plain) are, however, perfectly safe, and very convenient, as they can be placed anywhere, and are comparatively inexpensive as well. The square or oblong forms are the most convenient, but the cheapest and strongest as well is the circular form, constructed of stout sheets of the corrugated iron, bent to the proper form, and rivetted and soldered together.

These may be constructed of considerable size, and hold a lot of water, but they are by no means sightly objects, and are, on the whole, more suitable for use outside than under glass.

But in most cases, and for all ordinary purposes, there is nothing to equal a tank constructed of good sound brickwork, and well lined with fresh Portland cement. These may be made of any size or form, are practically imperishable, very strong, and comparatively inexpensive as well. They are usually, at any rate partly sunk in the ground, and may be built entirely below the surface if desired, in which case the work need not be quite so stout or strong as if constructed entirely above ground. Indeed, underground tanks or cisterns may be and frequently are constructed entirely of concrete, made of coarse gravel, burnt "ballast," or the like, and faced with a good coat of cement and sand only.

Nine-inch work, especially if put together with good mortar, to which a little cement is added just before use, and all the bricks soaked or wetted, will be found sufficiently substantial for all but very large cisterns, in which fourteen-inch work should be used. If formed of concrete the sides should be from 10in. to 12in. or 15in. in thickness, and have a good thick coat of cement put on inside as well. A concrete bottom is frequently employed, even for brick tanks, putting down a quantity of rough or broken bricks, etc., first, these being well "grouted" in with plenty of thin lime-mortar, and when set, covered with a coat of fine gravel-concrete, mixed with a little cement, and finally coated with cement and sand only. A layer or course of bricks laid on the flat, grouted in with thin cement and sand, is sometimes placed over the concrete, but this is not always necessary—much depends upon the character and solidity of the natural bottom.

The position of the tank, or tanks, in a plant-house of any kind is a matter of some moment, and needs a little consideration. As a rule, the larger they are the better, for the longer and more the water is exposed to the action of the atmosphere the better, and for the same reason open tanks should be preferred to such as are closed, or built underground. Especially where hard water from a well or spring has to be employed to any extent, the tanks should be as large as possible, such water being injurious unless well softened and chilled by exposure to the air. At the same time it must be borne in mind that very large tanks occupy a considerable area, and unless covered, at least in part, they reduce the space available for plants, etc.

One large nurseryman in Kent, whose houses, low span-roofed structures, each 100ft. by 12ft., are constructed side by side in extensive blocks, has two concrete tanks, about 6ft. wide by 4ft. or 5ft. in depth, constructed beneath each block, running at right angles to the houses, and placed at about 25ft. from each end. The water from the roofs of the houses is conducted by means of the wooden gutters described on p. 58 into these tanks, and access is obtained to them by means of trap-doors in the pathway of each house, but otherwise they are closed entirely in.

In another block of six similar, but wider houses, designed by the writer, there was a 6ft. by 5ft. tank, open at the top throughout, running right through the centre of the whole block, across the houses, and exactly in the middle. The beds and pathways were carried over this by means of stout planks, and the side-walls on brick arches, but otherwise it was open.

In and about Worthing deep brick and cement tanks, about 8ft. square, and standing a considerable distance above the ground, as well as being sunk some feet below it, are much used, but they are extremely ugly, and not very convenient. In my opinion, a tank of any magnitude should either be constructed right across the house, or else occupy part of the centre bed, or one of those at the side, for some distance. If placed in the centre, a light raised staging for plants may be constructed over it, and the space thus utilized, while at the same time the top is left practically open, and the water is easily accessible. Where the tanks are filled entirely or in part from the gutters outside, by gravitation, it is evident that the top of each tank must be a little lower, if only a few inches, than the lowest point of the gutters. An overflow ought always to be provided also.

In some cases, one or two rows of hot water pipes are conducted through the tank, or tanks, in order to slightly warm the water before use. Where this is done the water occasionally becomes quite hot, but in spite of the practice of some growers, I certainly do not consider this advisable, and am strongly of opinion that hot water is not beneficial to plant growth, generally. In cucumber culture tepid or lukewarm water may be all right, and even advisable, but really *hot* water should be avoided—it certainly promotes a weak and spindly, even if a rapid, growth.

Now, although it is a very easy matter to run the pipes through a tank constructed of brick and cement (though they must of course be built in after being fitted), it is quite a different and more difficult thing to prevent the tank leaking at the points where the pipes enter and leave it. The work generally, as well as the cement, may be of the strongest and best, and most carefully put in, but as the pipes become heated and cool again they expand and contract in length, with great force, if not very much, and the constant thrust and pull soon destroys the best cement and strongest work. I have, indeed, known not only several, but many instances where tanks, both of the kind now treated of as well as for bottom heat, have been rendered quite useless from this cause. There are only two ways out of the difficulty, one being to place the tank and arrange the pipes so that the latter may be *fixed* where they pass through the former, and expand and contract in one or both directions *from* it. Thus, tanks fixed in corners, or the like, are much less liable to fail from this cause than those placed on a straight line of piping, fixed at one end. The other method of preventing leakage is to run the pipes through other and larger iron collars built in the sides, with an annular space between the two, filled up with an indiarubber ring; this allows the pipes plenty of play, while effectually preventing any leakage.

I may mention that an extremely cheap and useful description of water tank for out-door use is an upright circular one, almost like a cask, but with straight sides, narrow at the top and widening towards the bottom, constructed of stout wooden staves, strongly hooped together, like the circular iron tanks mentioned on p. 96, these, though inexpensive and useful, are far from ornamental, however. For small structures a paraffin cask, with the head knocked out and burnt out inside, answers capitally. Where, as usual, the water from the outside gutters is led into a tank, a length of piping from the main, with a tap, should be fixed as well, for use in dry weather.

Bottom Heat Beds.—When these are required, as in forcing and propagating houses, for cucumber growing, etc., the usual and best plan is to place the pipes in a brick pit, with a false bottom consisting of sheets of corrugated iron or something of the kind laid over them, the soil or plunging material being placed on this again, as shown in the accompanying sketch (Fig. 69). A bed constructed of some sheets of this "galvanized" iron laid on cross-bearers 6in. or 8in. above two or three rows of 4in. hot water pipes, in a brick pit about 4ft. wide, and covered with 3in. or 4in. of cocoa-nut fibre refuse, as shown in the Fig., will afford a steady and genial bottom heat—enough for all ordinary purposes. Top heat must, however, be provided by means of other rows of piping, fixed in any convenient position above the bed, and this may be covered with small glazed sashes, or with loose sheets of glass laid over it, to conserve both the warmth and moisture. The cocoa-nut fibre must be kept constantly moist, as when dry it loses its conducting power and also becomes a refuge for hosts of insects.

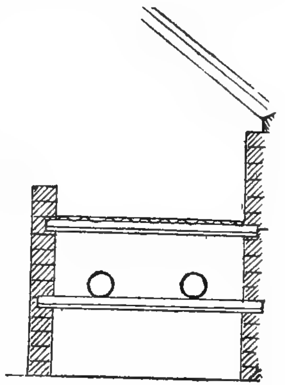


FIG. 69.

Fig. 70 shows the section of a propagating house 12ft. in width, and fitted with beds as described above, recently erected by the writer, and which afforded excellent results.

The old-fashioned hot-bed (in a house) was constructed with a hot-water tank beneath, the heat being obtained by running two or three rows of piping through a brick and cement or other tank, a covering of slate or the like being placed over, and a few inches of cocoa-nut fibre,

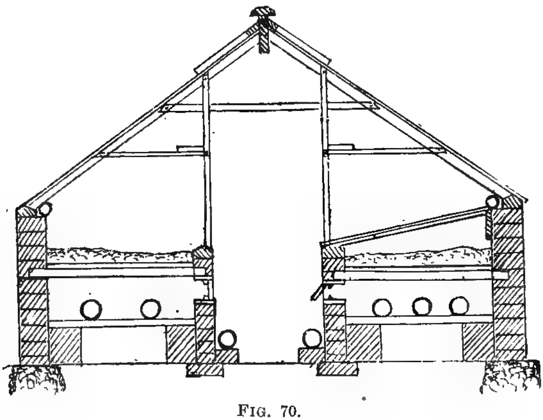


FIG. 70.

sand, fine ashes, or the like, on this in turn, in which to plunge the pots, etc.; a moist and genial bottom heat was thus secured, in which cuttings of soft wooded plants rooted readily, but the amount of moisture was sometimes found excessive, especially when the bed was covered in with glass. Another difficulty frequently met with in such cases is the liability of the tank to leak where the pipes enter and leave it, but this has been already treated of.

Yet another way of surmounting this difficulty is to construct a long, shallow tank beneath the bed, with a brick and cement wall, or division, up the middle, and introduce the end of a flow pipe in one side, and the return in the other, both at the same end. A gap or break in the dividing wall is left at the far end, and when the tank and pipes are filled and the fire lit, the water circulates freely round the tank, in much the same manner as it would do through pipes.

It is, however, found that in practice a dry bottom heat answers for most purposes almost if not quite as well as a moist one, and when a false bottom of an impervious nature, such as iron or slate, is employed, it is obvious that no moisture can ascend into the bed of fibre, etc., above, except perhaps to a very small extent through the laps or joints. With a porous material, such as perforated iron or zinc, kiln tiles, or the like, the case is different, but these materials are for the most part of a perishable nature, and for other reasons are unnecessary also, with perhaps a few exceptions. In all such work (propagaing, etc.) water *must* be given freely from above, and the cocoanut fibre must be kept constantly moist, or it loses its conductive power.

In a hot-bed of this kind the pipes should be placed side by side—horizontally—and not one above the other. They ought also to be as equally distributed as possible, as shown in the sketch, where, in a pit 4ft. wide, the pipes are placed at about 1ft. distance from the front and back walls respectively. If a strong bottom heat is required, three rows of 4in. piping should be placed in a pit of this width; and in extreme cases four rows will not be found too much.

Cucumber houses should be fitted with brick pits, 3ft. or 4ft. wide, on each side (in the case of span-roofed structures), see Fig. 8, or along the front only if a lean-to or three-quarter span. An arrangement of this kind is absolutely necessary where winter and early spring crops are required, though plants for summer cropping are frequently grown in mounds of soil laid on an ordinary raised staging, or even on a solid bed of ashes, etc., and as long as the warm weather lasts they usually succeed fairly well in this way, though not so well as in brick beds, even without the bottom heat. To provide this, one or two rows of 4in. piping should be fixed along the bottom of each pit, surrounding them with brickbats, over which some turf sods or littery manure is placed, and then the soil. Except in very cold places one row of pipes is usually sufficient, and, indeed, better than more in most cases. This should be a *flow*, but if two rows are put in let them be flow and return, the former being placed outside. Without the gentle bottom heat thus afforded the plants do not thrive in cold weather, though in the height of the summer it is unnecessary, and the fire may then be let out.

Note that this method of surrounding the pipes with brickbats or clinkers, and covering this with some rough materal must not be employed in the construction of hot-beds for propagating purposes, etc. Beds thus constructed are invariably failures, as the heat does not penetrate through to the surface of the bed with sufficient freedom to do any good. For all such purposes there should be a false bottom, or diaphragm, of galvanized iron or some *conducting* material, with a hollow chamber beneath for the pipes, and these should lie within 6in. or 8in. of the false bottom, without any obstruction between.

Another method of arranging a bed with bottom-heat is illustrated in Fig. 71, where over bearing bars of inverted ⊤ iron are fixed across the pit a few inches above the pipes, and perforated kiln-tiles, or pieces of plain iron grating laid between them, so as to form a perforated false bottom over all. On this is placed a few inches of broken bricks, rough cinders, or the like, and then some pieces of turfy soil, littery manure, or rough siftings, to keep the soil from being washed down. This method may be, and sometimes is, employed in the construction of cucumber beds, but being naturally somewhat more expensive, and as the other answers quite as well, if not better, there is no advantage in adopting it.

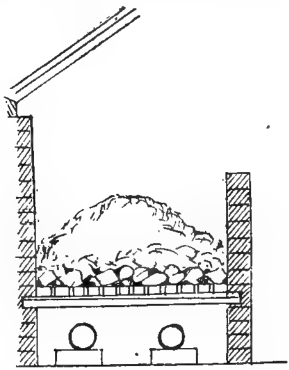


FIG. 71.

A small hot-bed, sufficient for any ordinary purpose, may be constructed in any greenhouse of the usual type, with raised staging and two or three rows of piping beneath, by enclosing a portion of these with a $4\frac{1}{2}$in. brick wall, as shown in Fig. 69. A sheet or two of the corrugated iron must now be laid on suitable bearing bars fixed across a few inches above the pipes, with a layer of cocoanut fibre above it, as before, and with a covering of loose sheets of glass, cuttings of most descriptions of plants may be struck, or tender seedlings raised, with great success, but the pipes ought to be kept constantly hot, of course.

Where there is a flue, this may be easily utilized to supply bottom heat, where necessary. Indeed, I would rather have a flue covered in closely, in a pit, such as described above, than outside, or standing free in the house, for in case of any smoke or sulphurous fumes escaping, this, being confined beneath the pit, would not do nearly the same amount of harm to the plants, etc., as would otherwise be unavoidable. This will, however, be more fully treated on in the section devoted to heating.

In pine houses, and occasionally elsewhere, somewhat similar pits to those recommended above, for cucumbers, are provided, but are filled with fresh tan, which affords a gentle warmth, and in this the pots are plunged. Such pine-pits are frequently furnished as well with a couple of rows of 4in. piping, laid near the bottom, in order to assist the tan in providing the mild but steady bottom heat which appears to be necessary to the welfare of the plants. Sometimes similar pits are provided in propagating houses, and filled simply with fermenting manure, but though sufficiently effective, this plan involves too much labour and waste in changing the material as required to be recommended.

Trellises.—In structures intended for the cultivation of cucumbers, vines, tomatoes, etc., which require to be trained over the roof, a wire or other trellis of some kind must be provided. In small houses it will suffice to screw some of the small iron rods with an eye at one end and a thread run on the other, that are obtainable at almost any ironmonger's, into the undersides of the bars at regular intervals, taking care to get them truly in line. Some moderately fine galvanised iron or zinc wire is now drawn through the eyes, and tightened up by any convenient means, one of the best being to fix a piece of light quartering, or better still a length of angle-iron, either with holes drilled along opposite each wire, at each end, in a line with the trellis. The wires may be secured at one end by passing the wire through each hole and twisting the end a few times round itself, in the usual way, and tightened at the other by means of a long screw and nut, with an eye for the wire at the other end.

This plan is, however, a comparatively clumsy and costly one, at least when adopted on a large scale, while the rafters are naturally weakened to a slight extent by the holes made in them by the screw-eyes. In large vineries, etc., a perfectly independent trellis should be provided, and in all such cases there is nothing superior to the method adopted almost universally in the Worthing district. This is to fix a length of stout angle-iron, bent at the ends so as to be securely bolted to the ridge and wall-plate, or muntins, at the top and bottom respectively, and drilled at intervals for the wires, as above. Intermediate bearing bars of slight flat bar-iron about 1¼in. by ¼in. in section are provided and supported by other short lengths of the same screwed to the rafters at the top, and bent to clasp the long ends at the bottom, these last being also drilled or punched for the wires. These intermediate rods, or bars, should stand 5ft. or 6ft. apart and the wires themselves may be placed 10in. or 12in. apart. The wires are threaded as before, and strained quite tight by means of long screws and nuts, or thumb-screws, at one end. Such a trellis is at once very light, strong, and practically imperishable, and if the bars are coloured pale blue or green, they really improve the appearance of the house.

For vines, the wires ought to be fixed 15in. to 18in. from the glass, at least; somewhat less, say 12in. to 14in., will answer well for cucumbers, while tomatoes may be trained still nearer to the glass, but not less than 9in. or 10in. in any case. When the trellis is too close to the glass there is always great danger of the foliage becoming scorched or "scalded" under a powerful sun, while the leaves of both vines and cucumbers are also apt to get flattened against the glass, when they scorch, decay, and stick to the latter, obstructing the light and creating a very unsightly appearance, as well as crippling the functions of the plants.

Pathways.—In most market and trade nurseries the walks or pathways usually consist of the natural earth, with a few barrows of fine gravel or ashes put down, more being added from time to time wherever a hollow place occurs and causes water to lie. A good layer of ashes make a nice, firm, and fairly clean walk, but the walk should be kept high in the middle, so as to throw off any superfluous moisture, especially in stoves and other structures where much water is used.

Sea-sand also makes a very nice, clean material for surfacing greenhouse paths, being soft and pleasant to the tread, but it should be kept just moist, so as to present a firm instead of a loose surface, and when employed in warm houses it is apt to become very hot, and burns or scalds the feet.

The best description of paving material for the walks of conservatories, corridors, and the like, is the flat, square Staffordshire tiles known as quarries, which are made in several sizes, and from 4in. to 12in. square. These are made in black or dark blue, red, and buff, and if a good quality of tile is used and neatly laid on a concrete bed, with cement, a very nice effect is produced by setting them alternately in two or three colours.

Concrete, formed of Portland cement and coarse or fine gravel, is probably the next best material. Concrete may also be made with hard burnt "ballast" (burnt clay), and even coal ashes and coke are sometimes employed, though none of these wear like gravel. Asphalte or tar paving is hardly suitable, owing to the quantity of tar employed, but good concrete makes a firm, clean, and perfectly sweet path or floor, easily swept or washed down at any time, and almost everlasting. Flag stones of almost any kind or size may of course be employed, if convenient, but these are usually somewhat costly.

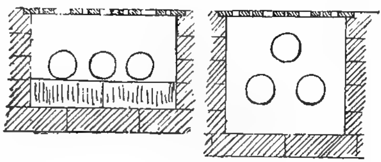


FIG. 72.

In conservatories and other large structures the heating pipes are frequently placed in trenches sunk beneath the floor or pathways, and when this is done a continuous grating of some kind must be employed (see Fig. 72). This method of heating, though rendering the somewhat unsightly pipes invisible, is on the whole not to be recommended, for reasons which will appear presently, but where adopted the light cast-iron gratings usually employed, though somewhat expensive, have a very neat appearance, and afford a perfectly dry, firm and sound footing.

Deep and consequently costly foundations to the walks or side walls are entirely unnecessary, and though sometimes put in, practically involve a positive waste of money.

CHAPTER VII.

PITS AND FRAMES.

Both ordinary frames and low brick or other pits are so valuable in gardens of all sorts and sizes, and are useful for such a variety of purposes, that it is scarcely possible to have too many of either, especially where early vegetables and so forth are required in abundance. For hardening off bedding and other tender plants, raising seedlings of many kinds, wintering carnations, auriculas, etc., as well as forwarding various vegetable crops, and for growing cucumbers, melons, and even tomatoes these contrivances are almost indispensable. In former years, before glass houses and heating apparatus became so cheap and common as they are now, a great deal of excellent work was done by means of pits and frames only, with no heat beyond that obtained from fermenting manure, leaves, or tan, and they are equally effective now, in capable hands. For many nearly hardy subjects, in which a dwarf and sturdy growth is indispensable, such as mignonette and other annuals in pots, and for growing cinerarias, chinese primulas, and others of a similar nature during the early stages, and so forth, low, airy pits and frames are positively unequalled.

The chief objection to the extended use of such frames, etc., is that no matter how severe or rough the weather may be, the lights or sashes must be opened to allow the occupants being attended to with water, etc., and a sudden change from a temperature of 60° or 70° to near freezing point is by no means conducive to the well being of the plants. This difficulty is however more formidable in theory than in practice, and by the exercise of a little

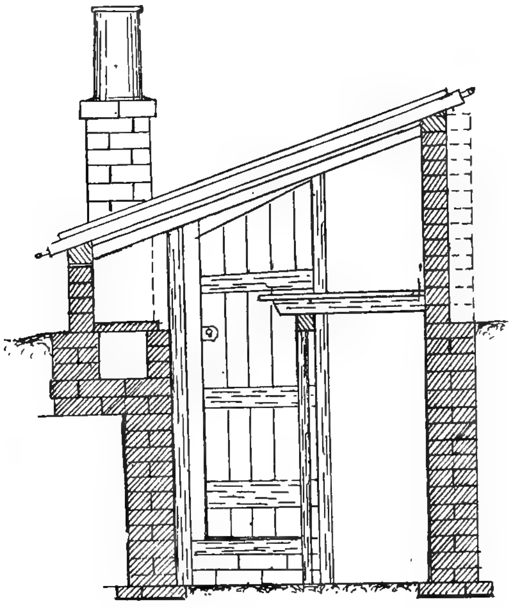


FIG. 73.

care very little damage from this cause is usually experienced. This obstacle is also easily surmounted, at a slight extra cost, by constructing a pit at any rate with a deep but narrow sunk pathway, with a small door at one end, to afford access to the interior, and enable the contents to be attended to without exposing them directly to the outer air.

Such a pit is illustrated in Fig. 73, and at the sacrifice of a small proportion of the area, enables the gardener to attend to his charges in any kind of weather, and, in fact, transforms the structure into a miniature greenhouse. Where economy is an object, a pit of this kind may be constructed very inexpensively, especially if the sides are formed of stout boards, or even of low banks of turf-sods. The cubic contents being small, such a pit may be efficiently heated by means of a couple of rows of 3in. or even 2in. piping, and a still less costly method would be to employ a simple smoke-flue, constructed of either bricks, or of 6in., or even 4in. glazed earthenware drain-pipes. These are very inexpensive, and when properly set, answer admirably, but this part of the subject will be dealt with more fully in the section devoted to heating.

Pits, properly so-called, and as distinguished from frames, may be divided into two classes, viz., those built simply on the ground, or on a very shallow foundation, and in which the plants stand on the solid bottom, or level ground —with a surfacing of ashes, to exclude worms, of course— and secondly, those constructed with a sunk pit inside from 2ft. to 4ft. or so in depth, which may be filled with fermenting manure or the like when required, and thus provide a more or less brisk bottom-heat. Those of the former class may, or may not, be heated by means of hot-water pipes, according to the purpose for which they are intended, but where necessary the usual method is to run an ordinary 2in. pipe all round the pit, placing the flow in front, or a flow and return of the same size is sometimes placed along the front or lower side.

Pits may be constructed with either lean-to or span roofs, and in some cases the three-quarter span form is adopted. As a general rule the span roof is employed in the case of long pits running north and south, and the lean-to, or in some cases the three-quarter span, where they trend east and west, or face south. The simple lean-to roof consists merely of ordinary lights, the usual size being 6ft. by 4ft., made to slide up and down on suitable bearing-bars, or rafters, but the three-quarter or full span forms are generally made with shorter lights on each side, hung to the ridge by means of suitable hinges or joints so as to lift up on the outside when necessary.

A usual and convenient height for the walls of such a lean-to pit of the usual (6ft.) width, is about 1 foot in front, and 2ft. 3in. or 2ft. 6in. at the back. A greater depth than this is occasionally afforded, but as a rule, where depth is required it is obtained by sinking the interior below the ground level. In a span-roofed pit both sides are of equal height, of course, and are as a rule comparatively low, seldom exceeding a foot or so.

The walls are usually constructed of brick—generally $4\frac{1}{2}$in. work—which should preferably be put together with cement mortar, but concrete or stout boards are frequently employed, and where a very cheap affair is required they may be formed of turf-sods neatly stacked together.

Slight plates, usually of 3in. by 2in. or 4in. by 2in. stuff must be placed on the walls, in the same manner as directed on p. 51. In order to make a good job these should be bevelled on their upper surfaces to the same angle as that of the roof. To carry the lights, bearing-bars of about 3in. by 1¼in. or 1½in. stuff, laid on the flat, and lightly dovetailed into and nailed to the plates are fixed across every 4ft., or whatever the width of the lights may be, with a "parting piece" of 2½in. by 1in., or ¾in. fixed on edge on the top of each, as shown in the sketch. A similar parting piece should be fixed at each end of the pit, to keep the end lights from slipping off sideways, and about ¼in. of "play" must be allowed to each light, so that it may run easily and not stick even in damp weather. Proper iron or brass handles must be screwed to each light, top and bottom, to pull or push them up and down by.

Pits intended to contain hot-beds of manure, leaves, etc., must of course be sunk in the ground some distance, as no less a depth than 3ft. to 4ft. of such material will retain its heat for any length of time. The portion below the surface must be lined with brickwork or concrete, and as a rule the front, back, and end walls are carried straight down to the required depth, a brick or concrete bottom being also usually put in. All brickwork below the surface ought, however, to be 9in. in thickness, whatever the thickness of the walls above may be. This class of pit has, however, a certain disadvantage in that as the manure, etc., decays and settles down it carries with it any plants, in pots or otherwise, that may be plunged or planted in it, thus rendering it impossible to train them to a fixed trellis of any kind.

An excellent type of pit in which this objection is done away with is constructed as follows:—In an ordinary deep brick pit (made, however, somewhat deeper than usual) a false bottom of perforated kiln tiles, or iron gratings, supported by suitable bearing-bars of T-iron, is fixed at about the ground level, or rather more than a foot below the top of the front wall. A lower chamber is thus formed, in which the manure or other fermenting material is contained; this is brought in, and again removed when necessary through doors in the back wall, opening on to a sunk path behind, as shown in Fig. 74. The warmth from the manure, etc., rises through the perforated false bottom into the upper chamber, where the plants are placed, and when exhausted the material is easily removed and replaced by fresh without disturbing the plants in

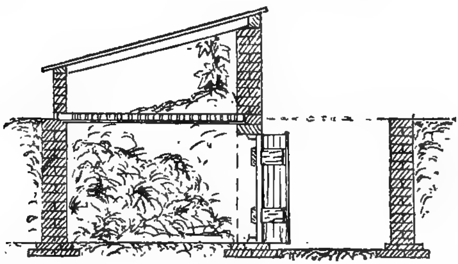


FIG. 74.

the least. This form of pit is an excellent and most useful one for the culture of melons, cucumbers, and other plants in particular.

The principal difference between a pit and a frame proper is that the former is a *fixed* structure, built on brick in concrete walls, and consequently a *landlord's* fixture, while a frame is a *moveable* affair, constructed entirely of wood.

A frame consists, as a rule, of a wooden "box" formed of tongued and grooved boards, which may be from ¾in.

to 1½in. in thickness, according to the size of the frame, a foot or so high in front, and 2ft. to 2½ft. at the back, and fitted with a sliding glazed "light" or sash. The usual size of a "single light" frame is 6ft. by 4ft., a double or "two-light" frame being 6ft. by 8ft., and those with three and four lights 12ft. and 16ft. in length respectively.

Full-sized 6ft. by 4ft. lights, made of 2in. stuff, and glazed with 21oz. glass, are, however, somewhat too heavy and cumbersome to be easily handled by anyone but a really strong man, and most amateurs, ladies especially, wlll find frames fitted with lights of about 5ft. by 3ft. each, and well made of 1½in. stuff, much more easily manipulated and generally convenient.

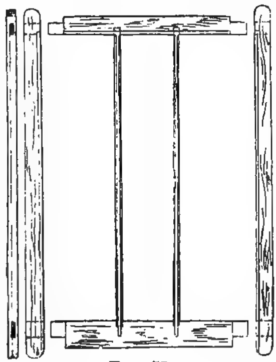


FIG. 75.

How to make a Frame and Light.—Supposing that the light, or sash, is to be of the usual size—6ft. by 4ft.—the first requisite is two pieces of 3in. by 2in. quartering, each 6ft. 6in. in length, one of the same size 4ft. (full), and one piece of 5in. by 1¼in., also 4ft. in length. Plane these up nice and clean, and as true (square as well as straight) as possible, and when this is done proceed to take a rebate out of each of the first-mentioned, on the upper side and inner edge, ¾in. deep, and about ⅜in. wide. Now cut a ⅝in. mortise, 2in. wide, in both ends of the two styles, or sides, 3in. from each end, or 6ft. from outside to outside; also corresponding tenons, $2\frac{1}{2}$in. long, on the ends of both the top and bottom rails, as shown in Fig. 75, taking care to cut the upper shoulders on the top rail $\frac{3}{8}$in. longer, so as to fill up the rebates properly. The projecting "horns" at each end of the styles should be rounded off neatly. Of course the mortises should be cut so as to allow of wedges being driven in top and bottom in the usual way. The joints are better made with thick white lead paint, or Stockholm tar, than with glue, and a $\frac{3}{8}$in. hole should be bored through each mortise and tenon (when putting the whole together), and a wooden pin be driven through tightly and cut off level on each side.

Now at $10\frac{1}{2}$in. from the shoulders at each end of the top rail cut two mortises, $\frac{1}{2}$in. wide and 1in. long and deep, with another one midway between them, to receive similar tenons cut on the ends of three lengths of 2in. by 1in. sash-bar. The bottom rail should be notched out 1in. long and $\frac{1}{2}$in. deep, in three places exactly opposite the mortises in top rail, the ends of the bars being cut to fit, leaving the head or "feather" (between the two rebates), 2in. or 3in. long, and tacking it down to the bottom rail with a couple of brads. Make all these joints with lead, like the others. The bars must, of course, be let into the bottom rail so that the rebates are flush with its upper surface. When the whole is fitted together and firmly pegged, procure a length of 1in. by $\frac{3}{8}$in. bar iron, 3ft. 9in. long, with holes for screws drilled at each end and opposite each bar, and when this is screwed on (on the under side) the light will be ready to be primed and glazed. One or two iron or brass handles should be screwed on to the top rail, of course.

The "box" is to be made of 1in. or 1¼in. boards, tongued and grooved and beaded at the edges. If the box, as usual, is to be deeper at the back than in front, a 9in. or 10in. board ripped down diagonally, or cornerwise, will afford a sufficient slope, half being fixed on each side, on the top. Remember that all the boards must be fixed with the *tongued* edges up—this is important. The box should not be made more than 5ft. 9in. in length, over all, to allow for the slope of the light and for this to overhang a little both top and bottom, when closed, but it must be a trifle *wider* than the light—¼in. is plenty—to allow of the latter moving freely up and down. Nail the boards tightly together at the corners, when all are cut and fitted, and then strengthen the corners with pieces of 3½in. by 3½in. quartering, ripped down diagonally, or cornerwise, so as to give a triangular section, fitting them inside the box, and nailing or screwing the ends of the boards firmly to them on every side. Now we want a couple of lengths, 6ft. 6in. each, of 4½in. by ¾in. batten, neatly planed up and lightly champfered off on the upper edges, nailing them on each side of the frame, along the top, and outside, so as to stand up 2in., or the thickness of the light, above the box. These are to act as guides. Fit the light so as to run easily, and see that it does not catch on the upper edges of the box, top or bottom. Give the box three coats of paint—dark green or blue, or lead colour—and glaze and paint the sash, and the job is complete.

Frames and lights may of course be made of any size, for particular purposes. Those to be fixed over propagating beds in warm houses are often made about 2ft. or 2½ft. deep, and 3ft. or so in width, according to the breadth of the bed. But many growers prefer to use loose sheets of glass, laid between lengths of light sash bar, tacked in place temporarily or otherwise, from front to back of the bed. These admit more light than sashes; air can be given to any extent, and the whole, bars and all, can be easily removed when necessary.

Double, or two-light, frames are usually constructed without any division, the inner edges of the lights being carried on a flat bearing bar, about 3in. by 1½in. strengthened by a "parting piece" of 2in. by ¾in. stuff, nailed on edge along the middle of the former, to separate the lights. This bar is dovetailed into and nailed to the "box" or boards forming the front and back, and thus serves the additional purpose of holding the latter firmly in place.

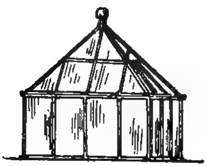


FIG. 76.

Pit-lights are supported in the same manner, and a division may of course be placed where necessary, and may consist of either brick or boards. Movable wooden divisions are very useful in long ranges of pits.

Handlights and Plant-Protectors. — The old-fashioned handlight, made with small pieces of glass set in a framework of lead or iron, and which is illustrated in Fig. 76, was largely employed for protecting early cauliflowers, lettuces, vegetable marrows, etc., and for raising small seeds. They are still employed to some extent, but have been in a great measure displaced by pits and frames of the ordinary type. Some handlights are, or were, made with movable tops, and some without, but where a considerable number are required, as to cover any extent of ground, these come very expensive. A bell glass, propagating glass, or "cloche" is shown in Fig. 77.

A very handy contrivance, answering much the same purpose as handlights, but much less costly, and even more useful, is easily constructed by a handy man, with some strips, or battens, of sound deal and other wood, and squares of glass. This is illustrated in Fig. 78, which almost explains itself, and the affair is easily put together. It should be made in 4ft. to 6ft. lengths, with moveable ends, so that any number may be placed end to end, as necessary. These will be found excellent for protecting rows of early peas, dwarf beans, etc., as well as for young lettuce, cauliflower, and other plants.

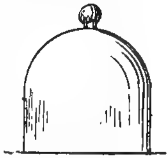


FIG. 77.

Shading.—Many kinds of greenhouses and stove plants of a somewhat delicate nature require to be screened in some way from the scorching rays of the sun in the summer season. Such subjects as the tuberous-rooted and other begonias, gloxinias, streptocarpus, most orchids, ferns, etc., must be shaded from strong sun or their beauty is soon destroyed, and even the foliage suffers, while the blossoms of many other greenhouse-plants, including even the sun-loving geraniums, may be preserved in freshness and beauty for a considerable time by means of a light shade.

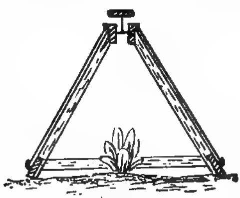


FIG. 78.

The simplest and most common method of shading is to brush a little whitewash, or something of the kind, over the glass—just enough to break the glare of the sun and prevent any scorching of the petals or leaves. This rough and ready method is adopted to a considerable extent in nurseries, where as a rule great particularity is not required. Ordinary lime-wash is frequently employed for this purpose, but though suitable enough in other respects it is open to the objection that it has an undoubted tendency to eat into the surface of the glass and destroy its brightness and transparency. It will, however, frequently "stick" if the lime is fresh, when hardly anything else will. A wash made with ordinary whitening to the consistence of cream, with a little milk, dissolved size, or oil added to increase its adhesiveness, is less objectionable than lime, and being whiter, looks better on the houses. A mixture of flour and water (not paste), with a little whitening added, possesses the advantage of becoming semi-transparent when wet, and therefore of obstructing less light when the shade is not required. The preparation known as "summer cloud," which is of a pale green colour, is also very suitable for the purpose under consideration, and is put up in convenient tins and easily applied.

But the great disadvantage of all these permanent shadings is that they obstruct the light and darken the house just as much when the shade is not required—that is, in the early mornings and evenings, as well as on wet and dull days—as at other times, and the tissues of the plants are thus weakened and rendered less able to endure the fierce rays of the sun when they do come. Now light strengthens and invigorates plant life of almost all descriptions, and the more they receive, and the fuller it is, the better. All that is required is just a light screen from strong sun only, with no shade whatever at other times, and in order to secure these conditions, and obtain the best results, a moveable blind of some kind becomes an absolute necessity. In private gardens of any pretentions, as well as in some of the better class of nurseries, most, if not all, of the plant-houses are consequently now fitted with blinds of some kind, and the question now arises, "which is really the *best* of the several methods of fixing them"? A blind fixed so as to be easily rolled up and down at will is easily fitted

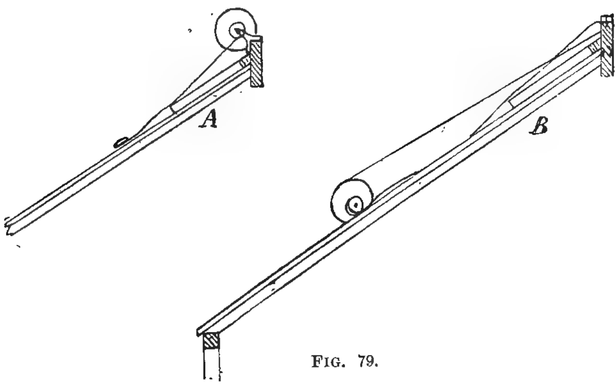


FIG. 79.

to a small structure of not more than 15ft. or 20ft. in length, but when a perhaps lofty roof of 50ft. or 100ft. in length has to be dealt with the task becomes much more difficult.

There are two chief methods by which greenhouse blinds (which are always placed outside, of course) may be fixed :—(1) with a *fixed* roller at the top (apex of the roof) after the manner of an ordinary window blind, as at A in Fig. 79, and (2) with the blind fixed at the top and a moveable roller fastened to its lower edge, as at B, in Fig. 79. The former would, at first sight, appear to be the better system, but in practice it has been found wanting, and all the best makers now fix their blinds by the second method. The great disadvantage of the first-named method is that a roller of more than a few feet in length is sure to "sag" more or less badly in the middle, under its own weight and that of the (possibly wet) blind, while there is no means of supporting it except at the ends. Then a multiplicity of short blinds and rollers is a thing to be avoided on several accounts, and lastly, the strain of several, or many, of the necessary brackets, fastened to the ridge, is frequently too much for this last, and causes it to give way.

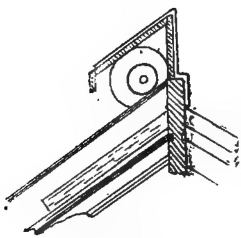


FIG. 80.

On the other hand, the roller is under the second method supported along every inch of its length by the blind itself—that is, if properly secured to it—and to some extent, also, by the bars, rafters, rods, or whatever it rests on. The actuating gear, or tackle, required by this class of blind is also more simple, as will readily be seen, than that of the other.

In brief, the upper edge of the blind is nailed to the ridge, or rather to a batten fixed horizontally along the roof just below it (the ridge), the lower edge being secured to a light roller of wood or some other material, which is actuated by means of a couple of large plain pulleys or wheels, fixed one on each end, over which pass cords fixed to the ridge at one end and running over another pulley placed at or near the same point. The loose ends being drawn brings the roller up, with the blind rolled on it, to the top. A long open-sided box, or pent-house, is fixed along near the ridge to receive the blind, and protect it from the weather (see Fig 80).

There can be no doubt of this being decidedly the best system of working blinds on greenhouse roofs. The details, such as the arrangement of the pulleys and working cords, may be varied to some extent, but the principle remains. But even by this method the rollers must be neither very heavy nor too long, or the blind will soon give way. A hollow metal tube—preferably of tin or brass—is superior to wood in its greater rigidity and lightness, and lengths of 20ft. or 25ft. should not be exceeded, even with this material.

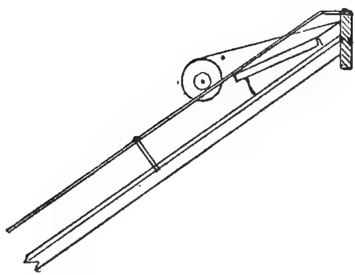


FIG. 81.

When the house does not exceed the above in length, a single roller may be employed, with a good sized pulley at each end, which should overhang the ends of the structure slightly. In this case the blind may rest, and the rollers run, right down on the bars or rafters, but where more than one length of roller is required the blinds and rollers must be kept up off the roof by means of iron rods fixed as shown in Fig. 81. Without these the pulleys could not work, or even be fixed in place, and beyond this it is found that better results are obtained when the blind is elevated a little way above the glass.

In order to enable one person to work both the cords, and raise the blind at both ends simultaneously, the cords are sometimes arranged as shown in the accompanying Fig. 82, with pulleys at the corner as shown.

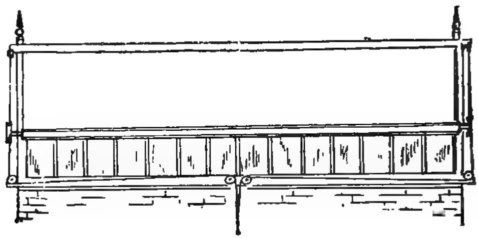


FIG. 82.

Plant-Protectors.—Any narrow glazed construction of the nature of a portable frame, whether span-roofed or lean-to, may be classed under the term of plant-protector, though as a rule these are made considerably *longer*, as well as *narrower*, than ordinary frames. An excellent type

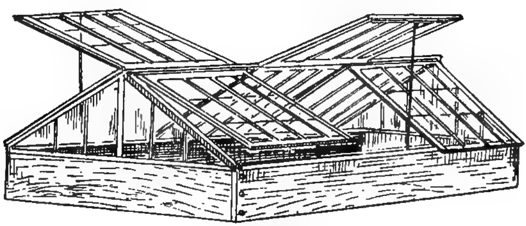


FIG. 83.

of plant-protector is shown in Fig. 83, in which it will be seen that the lights on each side are hung to the ridge in the usual manner, and are lifted up to allow of the contents being attended to.

Plant-protectors may be of any length, and from 2ft. to 6ft. or so in width, and are extremely useful for protecting or encouraging the growth of plants of many kinds, both in pots and planted out. For hardening off bedding plants and similar purposes they are of course quite equal to frames, and on the whole, rather more convenient.

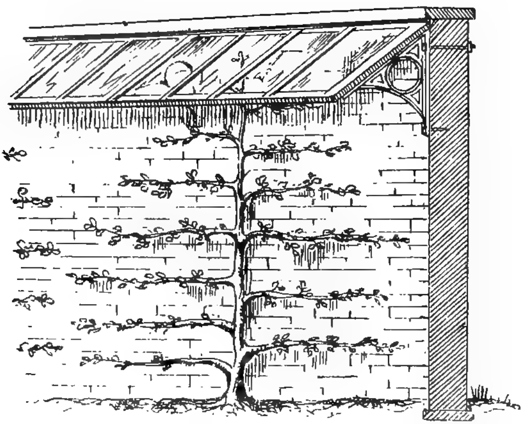


FIG. 84.

An important point in both their construction and management is to provide against the lights, when opened, falling or being blown back, which is almost sure to lead to serious results, especially if a man or lad is stooping down to attend to the occupants. Unless, therefore, the lights are secured by some means, it is always best to have an assistant to hold each light up firmly when opened.

Glazed Copings and Wall Covers.—A coping is merely a kind of shelf fixed along near the top of the wall, over any plants that are nailed or trained to it, as shown in Fig. 84. Copings, which may be from 1ft. to 2ft. or more in width, and must be fixed on brackets, with the front edge some inches lower than the back, in order to throw off the rain, are usually, and most properly, constructed of a stout glazed framework, though in some cases a few lengths of wide board, or plank, are made to do duty, but as this obstructs the light to a considerable extent, it cannot be recommended.

Such a plain coping protects fruit and other trees on walls to a considerable extent, not only from rain and hail, but from frost also, which usually strikes directly downwards. By the way, keeping the rain off the trees thus, though all right at certain seasons, is by no means beneficial at other times, so that it is a good plan to have all such copings easily removable.

But further, such a coping, if only a narrow one, enables ordinary garden netting, or mats, etc., to be easily hung in front of peach or other trees when in bloom, thus securing a good "set" even when the weather is cold or rough, as it too frequently is in the spring. This affords a still greater amount of shelter, while admitting a good deal of both air and light. A single or double ply of netting may be put up as soon as the first blooms begin to expand (but not before), and allowed to remain until the fruit is well set, and safe, with the greatest advantage, but mats, etc., should be removed on fine and mild or sunny days, and again replaced at night and when the wind is cold, or snow, hail, or cold rain falls.

The addition of some spare frame-lights, or specially constructed sashes of suitable size, at once transforms any ordinary coping of a fairly substantial character into a wall-cover, this being really a kind of narrow, steep-pitched house erected against the wall, in which peaches, nectarines, figs, choice plums, and even vines, may be grown to perfection, and full crops of the finest quality practically ensured. The lights may be fixed in an upright position, as in Fig. 85, or with a moderate inclination outwards towards the base, as in Fig. 86. The best way to fix them is by means of a light grooved plate fixed to the front of the coping, as shown, and a stout sill at the bottom, raised a little way off the ground, with a stop or bead nailed along behind, and a couple of thumb-screws, buttons, or the like to each light, in front, by means of which they are secured in place.

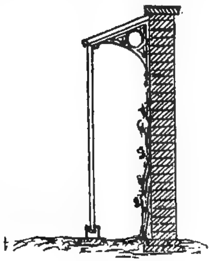


FIG. 85.

By employing a coping, or roof, of sufficient width—3ft. to 4ft.—and thus bringing the front lights out to a moderate distance from the wall, such a cover may be converted into a kind of narrow house, wide enough to allow of the trees being attended to from a narrow path arranged inside the structure, and also of a row of tomatoes, figs, or other plants in pots being accommodated along the front, as shown in the sketch (Fig. 87).

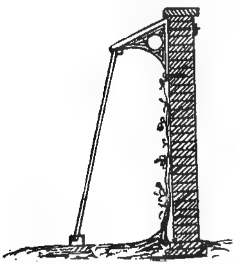


FIG. 86.

But in all cases where the wall is completely covered in as above, some provision must be made for ventilation, or the temperature inside will be liable to rise to an injuriously high point under the influence of bright sunshine. To a certain extent air may be given, in mild weather, by sliding the front lights along so as to leave a small aperture between each, but with a cold wind blowing a little top ventilation only should be given. This may be provided by fixing a square of glass here and there in a small sash or frame, hung at the back and made to open with a casement stay or the like, or by leaving a narrow aperture all along either at the back of the coping, against the wall, or beneath its front edge, above the front lights, these being closed with narrow wooden flaps, with hinges, to be opened and closed at will.

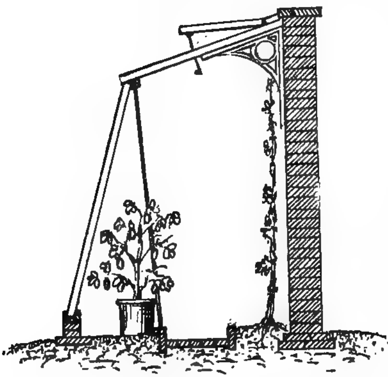


FIG. 87.

Conservatories.—The real meaning of the word conservatory is a house (or place) in which to preserve, or *keep*, plants, as distinguished from a structure intended for growing purposes only. A conservatory may consequently be of any size, from quite a tiny affair, only a few feet square, to the enormous structure at Chatsworth, which covers an acre of ground, and may be built in any style, from the plainest lean-to to an elaborate structure with a lofty curvilinear or otherwise ornamental roof, cusps to the side-lights, coloured glass, cast or wrought iron pillars, a super-roof for the ventilators, and so forth.

In gardens of any pretentions, however, the conservatory is a house of considerable size, of more or less ornamental construction, and usually either attached to the mansion, or easily accessible from it. In style or pattern conservatories vary greatly, and the design is usually made to harmonise, as far as possible, with the architectural style of the residence. Indeed, in too many instances, the welfare of the plants is sacrificed to the points of architecture and ornamentation, and as a consequence, many such structures are little better than death-traps for tender or delicate plants.

A design for a handsome lean-to conservatory is given in Fig. 92, designed and erected by Mr. Duncan Tucker, of Tottenham. A smaller and less pretentious structure, suitable either for growing purposes or as a conservatory, is shown in Fig. 93. But it will be evident from what has been stated above, that no definite instructions can be given, and the pattern or style to be adopted depends chiefly upon the taste of the owner and the ideas of the architect, who must of course be consulted when the structure is erected simultaneously with the mansion.

Speaking generally, however, the chief points to be studied in the construction of a conservatory of any kind are as follows :—(1) That it shall be as roomy as possible, consistent with other considerations ; (2) loftiness, to a moderate extent, both to provide abundant head-room, and also to allow of climbers of various kinds being freely trained over the roof—to this end the sides should be constructed with side-lights of considerable height ; (3)

plenty of heating power, so that a comfortable temperature may be maintained even in severe weather, when this house is frequently most resorted to, without trouble, or having to push the fire much; (4) free ventilation, both at the top and bottom, coolness in summer being quite as desirable as warmth in winter; and (5) abundance of light, consistent of course with the necessary amount of ornamentation. Firm, clean, and dry pathways, formed of either suitable paving tiles, concrete, or the iron gratings employed to cover the pipes, where these are placed in trenches, are also of great importance, and if not sunk in pits as above, the pipes should be kept out of sight as much as possible.

Small "ladder" or flat stages should be placed here and there, to accommodate pot plants, such as hyacinths, tulips, pelargoniums, begonias, and others, but this must not be overdone in large and tastefully arranged houses. The chief dependence should be placed on large permanent specimen plants, such as palms, large ferns, camellias, oranges, fuchsias, etc., either planted out in borders, or grown in large pots, tubs, or boxes, and on carefully arranged groups of plants in pots, large and small, standing on the floor, and altered or re-arranged from time to time, as required.

All permanent beds and borders must be well-drained, and composed of the freshest and best materials, of which fresh loam from an old meadow, peat, leaf-mould, nearly fresh but well-dried manure, and coarse sand or grit, form the principal components. Such borders need not exceed from 2ft. to 3ft. in depth. Dead walls should have a trellis fixed a few inches from them, to which climbing plants may be trained, or better still, be carefully wired—and plenty of pillars, as well as tie-rods, etc., in the roof are desirable, over which other climbers may be naturally festooned. Panels of lead-lights filled with coloured glass are now frequently employed in the construction of this class of house, and if not overdone, they do little, if any, harm to the plants.

Among the numerous forms of decoration as applied to conservatories and ornamental plant-houses are the following :—

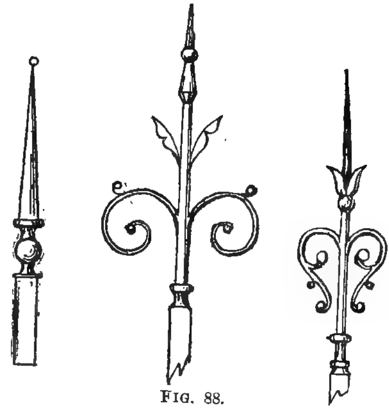


FIG. 88.

Finials, shown in Fig. 88, are wooden or iron spikes or points fixed at each end of the ridge. They are made in various patterns, of cast or wrought iron, and wood, and add considerably to the appearance of the structure.

Ridge-cresting, which consists of ornamental iron — or wood—work fixed along the ridge, as shown in Fig. 89. The light cast-iron ridging is made in several patterns, and besides being much more elegant than that made of wood, is considerably stronger

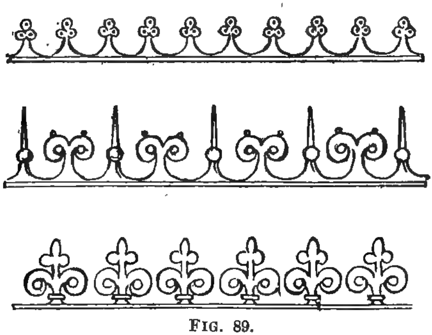


FIG. 89.

and, barring accidental breakage, is practically everlasting.

Cusps are small ornamental pieces of iron or woodwork fixed in the upper corner of the side-lights, as shown in

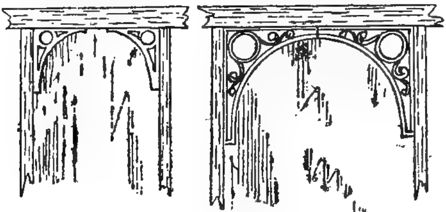


FIG. 90.

Fig. 90. These break the hard, square lines, and improve the elevation greatly.

A line of small leaded lights, fitted with variously coloured glass, is now frequently introduced just below the

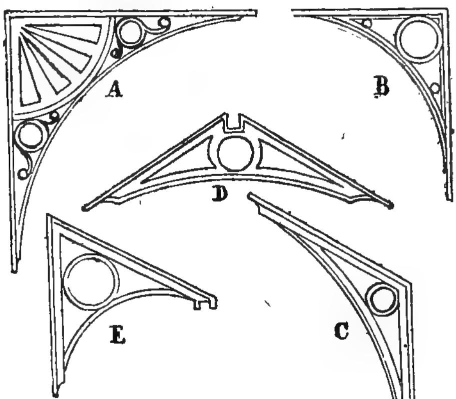


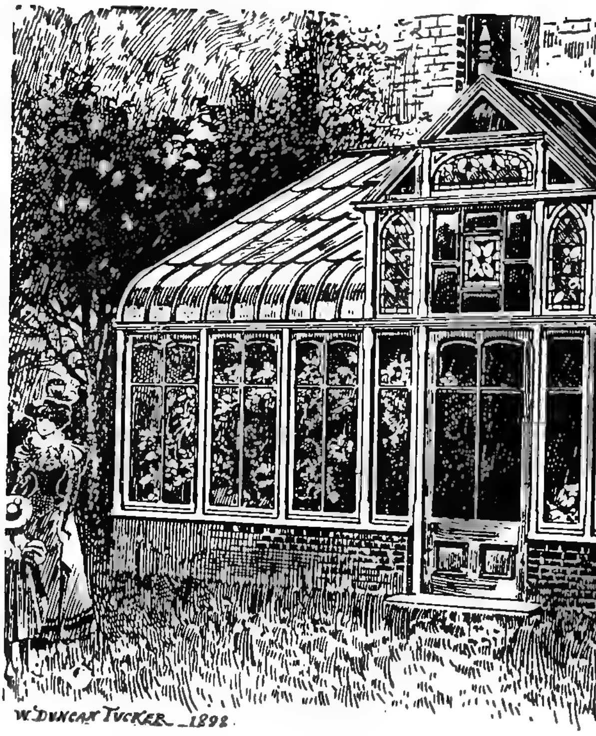
FIG. 91.

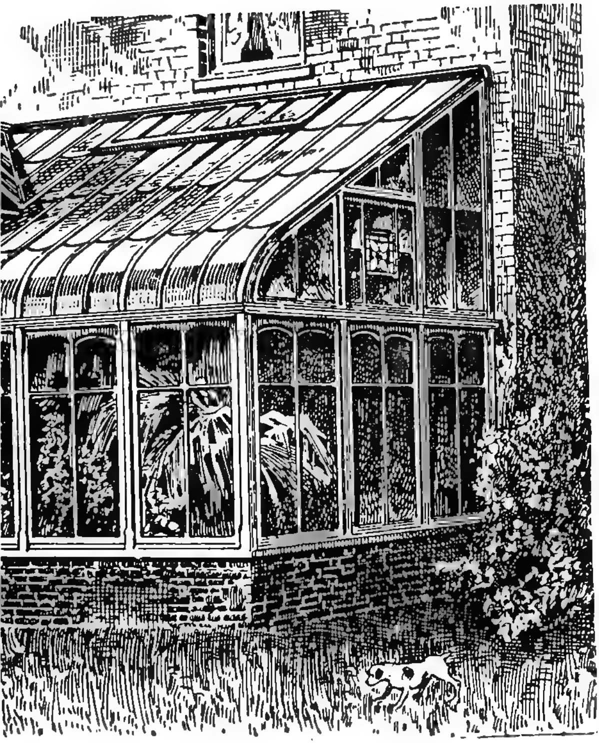
eaves of conservatories, and if tastefully done, affords a very pleasing effect.

Fig. 91 shows various forms of brackets, spandrils, etc., in cast iron. Those at A and B are square brackets, to support shelves, etc.; C is an obtuse-angled bracket to be fixed at the foot of rafters, D a spandril for keeping rafters in place at the ridge, and E a bracket for sustaining wall-copings.

Travelling Greenhouses.—An entirely new departure has been made quite recently in the introduction of what are known as "travelling greenhouses." Speaking briefly, these consists of a stout and well-constructed glass roof, strongly tied together, carried on a number of small iron wheels, with flanges, which are fixed just below the plates, and run on narrow iron rails resting on stout horizontal plates, which again are supported by low brick walls, or piers of the same placed at intervals. The sides are so constructed, by means of overlapping woodwork, as to be almost, if not quite, air-tight, and the lower part of the ends, which are usually constructed of wood, are made separately, like shutters, and hung from a kind of plate so as to lift up when required, and allow of the structure passing over any crops of a moderate height without injuring the latter. The heating apparatus, where any is provided, must of course be portable with the house, or else be of a temporary or easily removable description. In the former case the pipes are usually slung from the roof, near the eaves, and the boilers are either portable, or else so situated and fitted as to work either to right or left, as required, without removal.

The object of this method of construction is to enable the glass roof to be pushed over at any time, or when necessary, on to another crop or plot of land, and from


W. DUNCAN TUCKER _1898



this it will be plainly evident that the rails, etc., must be at least twice the length of the structure, if not more. In fact, in order to obtain satisfactory results, in market garden work, at any rate it is advisable that the plot of ground fitted with rails should be three times the length of the glass roof, in order to provide for a suitable rotation of crops.

I must confess to being unable to perceive the utility, or rather the real importance, of this class of house in the first instance, but a little consideration quickly showed that the system possessed important advantages, and like other really good things, undoubtedly improves on acquaintance. One of the best uses that such structures can be put to, and the one that first commended the idea to myself, was that of sheltering a batch of chrysanthemums, planted outside, after a summer crop of tomatoes was over. It will readily be seen that it is only necessary to plant out a batch of young "mums" of suitable varieties in the next plot (within the rails) in the spring or early summer, and when these require protection, say at the end of September, and the "toms" are over, the house only has to be pushed over—which half-a-dozen men can easily do in a few minutes, by the way—to accomplish the desired object. In the spring the house may be pushed over on to plot No. 3, which may be planted with tomatoes again, the chrysanthemums being grown this season on the plot occupied by the tomatoes previously, and so on. Again, a number of Tea or H. P. Roses may be easily forced by merely running the house over them in the early spring, after a late crop of tomatoes on the next plot, or even after the "mums" are over.

These houses are also useful for early potatoes, lettuces and other salad plants in the winter and spring, as well as for cauliflowers in the autumn, and also for forcing narcissus and other bulbs planted directly in the ground, and for numerous other purposes which will quickly suggest themselves to the practical nurseryman or market grower. There are certain minor disadvantages connected with the system, which is doubtless only in its infancy yet,

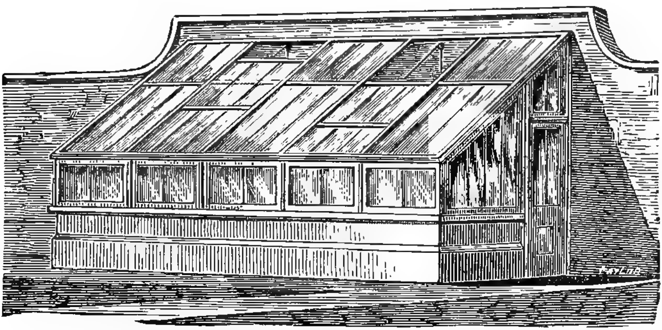


FIG. 93.

but these will all be surmounted in time, no doubt, and the principle itself is an admirable one.

The travelling greenhouses were invented by Dr. Pickering, of the Horticultural Travelling Structures, Ltd., of White Street, Moorgate Street, London, who also erect them for growers, etc., on very moderate terms. A large number of these houses have been erected by the firm for several of the leading growers of tomatoes, grapes, cut flowers, etc., for market, at various points along the south coast and elsewhere, during the last few years, which

FIG. 94.

plainly proves their appreciation by the eminently practical growers in that district.

When these men, who have naturally a keen eye to the "main chance," take up anything, one may be quite sure that there is something in it. A rough idea of the system may be gathered from Fig. 94.

CHAPTER VIII.

GENERAL REMARKS ON HEATING.

The chief objects of growing plants under glass are (1) to enable more or less tender exotic (*i.e.*, foreign) subjects to be successfully cultivated in our comparatively cold and always changeable climate, and (2) to "force" various fruits, flowers, and vegetables into an abnormally early bloom, etc., and thus induce them to afford their produce more or less in advance of their natural seasons. With very few exceptions, neither of these objects can be attained without the aid of artificial warmth, obtained by some means, and though the unheated greenhouse (which will be considered more fully presently) is certainly valuable for some purposes, yet its capabilities are limited, and it is of comparatively little value for either the culture of really tender plants (*i.e.*, such as are destroyed by any appreciable amount of frost), or for the forcing or forwarding of garden produce of any description, that is, beyond a certain very limited extent.

A well-constructed glass-house will protect its occupants from several degrees of frost—often as much as 6 or 8 degrees—if not of too long continuance, and especially if the structure occupies a moderately sheltered situation, but when the thermometer falls below about 25 degrees Fahr., or if even a less degree of cold is maintained for more than a few hours, the low temperature will gradually penetrate to the interior, and soon leave its mark on any plants of a tender or delicate description. Plants standing near the glass are naturally affected first, and it is a well-known fact that the tissues of such as are in a comparatively moist condition at the time, or have been grown rapidly in rich soil with plenty of water, are decidedly more tender or "soft," and therefore liable to injury from frost, than those of others that have been to some extent starved or kept on a short allowance of moisture and nutriment for some time previously. Thus common "geraniums" (zonal pelargoniums) may be rendered practically hardy, and be safely preserved through an ordinary winter in a totally unheated structure, simply by affording them no water whatever, from the middle or end of November—or whenever the cold weather sets in—until some time in March, when the spring returns. Under this treatment the plants lose nearly all their leaves, and become mere "bare poles," but they will not perish, and when subjected to the influence of warmth and moisture again in the spring, quickly burst into luxuriant growth and blossom again.

Much may also be done towards preserving more or less tender plants through the winter in unheated houses or pits by covering the glass with some non-conducting material in frosty weather, and also by plunging the pots in ashes, cocoa-nut fibre refuse, or the like—but this will be more fully dealt with presently.

The first attempt at heating, in connection with horticulture, in this country was made, I believe, at Belvoir Castle, where great fires were kept burning during the spring and early summer against the back wall of a lean-to vinery, though if I remember rightly the fires were employed before the glass, the latter being added afterwards. The wall being thus kept constantly warm induced the vines to break into growth and ripen their fruit earlier and better than usual. This was of course a very rough and frightfully wasteful method of heating, but it was the first step in the science of forcing, though soon abandoned in favour of the smoke-flue.

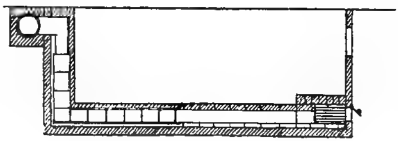


FIG. 95.

These smoke-flues, so-called, which may still be found in many old-fashioned vineries, etc. in country gardens, were constructed of brickwork, and led from a furnace built outside one end of the house, usually along the front and across one end of the structure into a stack or chimney at the other end, as shown in Fig. 95. Flues are still employed by some growers for certain purposes, and indeed a combination of flues and hot water pipes is probably the most economical of all methods of heating, but though by no means expensive to construct, flues are certainly rather extravagant in fuel, and moreover afford a dry and somewhat harsh warmth, unfavourable to the growth of delicate plants, especially when the brickwork becomes at all overheated.

Two other serious objections to the flue system of heating are the constant danger of cracks or flaws in the masonry occurring, when the smoke and sulphurous fumes will escape into the house, and may do serious damage. The young growth of maidenhair and other ferns, as well as some other plants, is so delicate as to be quickly destroyed by even a slight escape of this kind. The second objection is the danger of the draught becoming stopped by contrary winds—for all furnaces and flues draw better with the wind in certain directions than others—or by the chimney, which is usually at a distance from the furnace, becoming cold. When this occurs the fumes must go somewhere, and however sound the brickwork may be, a portion is sure to find its way through into the interior of the house, to the certain injury and possibly total destruction of the contents, in whole or part. This difficulty is however obviated by employing the double flue described farther on, which possesses several important advantages over the old-fashioned or single flue.

On the other hand, a fire contained in the brick furnace of a flue will (if not allowed to burn away too rapidly) remain alight much longer than one of the same size and character in a boiler furnace and surrounded by iron and water only, and farther, when once the mass of brickwork becomes thoroughly heated it will retain its warmth and prevent the ingress of frost to the house for some hours. Neither does such a fire require such frequent attention as those in the boilers of a small hot water apparatus. In fact, it may be safely affirmed that a well-constructed flue is a more dependable and less troublesome method of heating small structures than any of the usual type of hot water apparatus, excepting, of course, those constructed to burn gas or oil (paraffin). But these last are comparatively costly, both in the first outlay and in fuel, as well as being open to certain objections, which will be dealt with presently. In careful hands, and particularly where only a moderate degree of warmth is required, a well-constructed flue is a method of heating by no means to be despised, and excellent work may be and is done by this means. The different forms of flue will be fully described later on.

Heating by means of hot water is, however, undoubtedly the safest and altogether best, if not, perhaps, the cheapest means of heating horticultural structures of all kinds, and those of considerable dimensions in particular, and it will therefore be considered first.

A few of the advantages of heating by means of hot water carried in pipes of iron or some other metal—copper is the best conductor, but its cost renders it out of the question, except for quite small affairs—are (1) that the heat given off is so mild and gentle, it being impossible for the temperature of the pipes to rise above 212 degrees Fahr., while it usually ranges considerably less than this ; (2) the heat is easily carried to any point, and may be equally distributed over a house of any length or width merely by a proper arrangement of the pipes ; (3) that with the boiler and furnace altogether outside the house there is no possibility of any smoke or fumes gaining an entrance ; and (4) its perfect safety.

Heating by means of steam has been, and in some few cases is still adopted, especially in the United States, etc., but though possessing certain advantages the pipes are apt to become over-heated and parch or burn the air, while there is also more risk of an explosion in frosty weather than under the low-pressure hot water system. Where the exhaust steam from engines of any kind is available, this may be very economically employed to heat any green- or forcing-houses, with good results, a few slight precautions being observed. It should, however, be borne in mind that the act of discharging the waste steam into such pipes, instead of directly into the atmosphere, is almost certain to cause a slight back-pressure in the cylinders of the engine. In heating by steam the pipes should be fixed with a slight *downward* inclination from the point where the steam enters them to the farthest extremity where the exit is, so as to allow the condensed water to run away freely. A comparatively small outlet pipe, or cock, placed at the farther end, leading into a drain, etc., will suffice to carry off the condensed water.

Heating by means of hot air—of which the old-fashioned flue is one form—has also been tried and employed to some extent, but the chief objection to its use, as to that of steam, is that the pipes, or radiating surfaces of whatever kind, are apt to become overheated and burn the air. It is also a difficult matter to secure a proper and regular circulation over considerable areas, as easily accomplished with hot water, and to have all, or the greater part of, the heat in one place is fatal to good plant culture.

Stoves of the ordinary close type, on the slow-combustion principle, such as the little "Tortoise" stoves (without hot water), are sometimes used for heating small plant-houses, but though useful to a certain extent where frost only has to be excluded, they are open to several serious objections, such as (1) their liability to become overheated; (2) the dust and dirt unavoidable where the stove has to be fed and cleaned inside the house, not to mention the risk of an occasional down-draught and its consequent deadly fumes; and (3) even where the fire is carefully managed, and no over-heating occurs, the flue-pipe as well as the stove itself gives off a harsh, dry heat, which dries and parches the plants, and effectually prevents anything like healthy growth. Lastly, the heat being given off chiefly, if not entirely, at one point, a proper distribution is impossible.

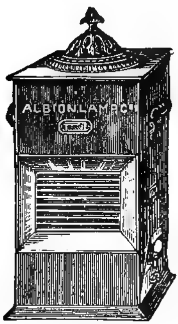


FIG. 96.

Stoves of the same type, but lined with fire-tiles or terra-cotta are much less objectionable than the last, but even these are not devoid of faults by any means.

We now have to consider the little paraffin lamp-stoves so largely employed for heating small greenhouses, etc., in all parts of the country, and of which an illustration is given above (Fig. 96). These are merely oil-lamps on a large scale, with one or more broad wicks, and afford enough heat to warm small structures up to 8ft. or 10ft. long, by 5ft. or 6ft. wide, sufficiently to exclude frost. The weak points of this class of stove are (1) that the products of combustion escape directly into the atmosphere of the house, and this is of course anything but conducive to the health of the plants; (2) the unpleasant odour that generally arises from their use, and which clings to the house even when the stove is not in use; and (3) the risk of the flame getting too high and smoking. When this occurs the whole of the interior of the structure, with its contents, become covered with a greasy soot, which is at once very unsightly, injurious, and difficult of removal.

In all cases these stoves must be kept scrupulously clean, oil of the best quality only being employed, and if carefully trimmed and not allowed to burn too high, a well-made stove may be used without any injurious effects, and indeed, with fairly satisfactory results. But nothing beyond thoroughly excluding frost must be attempted, and the stove be only used when actually necessary, that is to say, when the thermometer outside falls below about 36 degrees Fahr. Air should also be freely admitted whenever possible, in order to allow of the speedy escape of any fumes, and get rid of the unpleasant odour. The improved and superior makes of these stoves, however, give off little or no smell, and these only should be used, avoiding the common or cheap kinds. Although thus useful, in careful hands, for smal structures where only a low temperature is required, these stoves are entirely inadmissible for heating large houses, or for anything of the nature of forcing. In some cases it is found advisable to place a pan of water on the top of the stove, when burning, but in others the combustion alone produces quite sufficient moisture in the atmosphere, and occasionally rather too much.

But decidedly the best and least objectionable form of oil or gas-stove (without hot water pipes) are those constructed on the "radiator" principle, as it is called, one of which is shown in Fig. 97. In these it will be seen that the fumes or products of combustion from the lamp or burner (at A) ascend through a vertical tube B into another large horizontal tube C, placed across the top of the last; from this there are only two outlets, these being on the *lower* side, one at each end, leading into two other vertical tubes D D, which are also open at the bottom, with a small pan beneath each to receive the condensed moisture, etc. The large tube C receives and radiates a very large amount of heat, and by the time the fumes from the lamp have been at any rate partially condensed in the tubes C and D D, what remains and escapes at the apertures E E is practically innocuous. Even gas, of which the fumes are as a rule very deadly to plant life, may be burnt in a stove of this kind with little or no injurious effects on the occupants of a greenhouse, while as there is no flue or means of escape from the stove, the whole of the heat generated by the flame is utilised in the structure. The stove illustrated in Fig. 98 is an excellent example of this system.

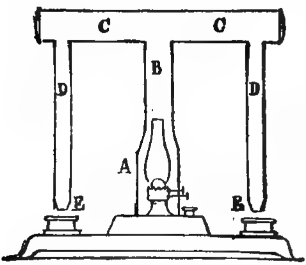


FIG. 97.

There are now a considerable number of different forms or adaptations of this stove on the market, some with two, three, or more cross-tubes, and others again with smaller tubes, open at each end to the air, placed within the larger heating tubes. By this means the heating surface is considerably increased, while the actual size of the apparatus remains the same. Most of these stoves are on the whole steady and regular in action, nearly or quite innocuous, economical as regards fuel, and of considerable use for the purpose in view. They are, however, decidedly inferior, for the growth of choice or delicate plants, to a proper set of hot water pipes. Illustrations of some of the leading forms will be found a little farther on.

There is also a class of apparatus consisting of a few feet of hot water piping, usually of small diameter, heated by a small copper or other boiler, constructed to consume

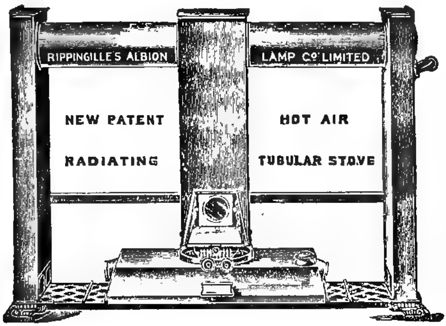


FIG. 98.

gas or oil (paraffin) as fuel. These are admirably adapted for heating small conservatories and plant-houses, where only a moderate temperature is required, and as a flue (pipe) is usually provided to convey the products of combustion outside the house this class of apparatus is entirely innocuous. The flame (which takes the place of a fire) can be regulated to a nicety, and being constant and regular, there are no fluctuations of temperature; where gas is employed an atmospheric burner must be used, but oil stoves are fitted with the usual broad flat or circular wicks. The only disadvantages are that the commoner and cheaper forms of boiler are apt to be very extravagant in fuel, in proportion to the heat obtained, an excessive proportion of the caloric generated by the flame passing away up the flue and being wasted. Again, unless a wind-proof cap is fixed on the top of the flue pipe there is always a risk of the flame being blown out by a sudden down-draught in stormy weather, and though with oil such an occurrence leads to no more serious harm than the loss of heat, if the flame is thus extinguished during the night where gas is burnt, this of course continues to escape until turned off, and a serious explosion may take place. The better types of boiler, however, utilize a very high percentage of the heat generated, and are consequently fairly economical in working, while one of the patent wind-proof caps fixed on the flue-pipes will effectually prevent all down-draught, and render any accident of the kind referred to impossible.

CHAPTER IX.

HEATING BY HOT WATER.

This being undoubtedly the most satisfactory and generally useful method of heating horticultural structures of all kinds, will be treated first.

The principle or basis of all hot water heating consists in the well-known fact that water, when heated, expands considerably in volume, and its specific gravity being reduced thereby, it rises ; also that as it cools again it contracts, and, if allowed to do so, again falls. This may be easily demonstrated by applying the flame of a spirit lamp to one side of a test-tube or the like filled with coloured water.

Following out this principle, the boiler and pipes in all heating apparatus of this kind are so arranged that as the water in the former becomes heated it rises into one set of pipes leading out of the top (of the boiler), and through these to a point which may be some considerable distance (often some hundreds of feet) away from the boiler and fire. By the time this farthest point has been reached it will have parted with a good deal of its caloric, or in other words will have begun to cool somewhat ; it is then allowed to fall into another set of pipes placed on a lower level, and is thus led back to the boiler, which it re-enters at the *bottom.* Here it again becomes heated, again rises, flows through the pipes, and returns, so that a constant current, or circulation, as it is termed, of the water in the pipes is maintained during the whole time that a fire is burning in the furnace. Fig. 99 shows a very simple arrangement, in which A is the boiler, B the "flow" pipe (which may however be separated into two, three, or more currents), C the farthest point (where an air-pipe D must be placed to allow any confined air or steam to escape), and E the "return" pipe, or pipes, through which the cooled and consequently comparatively heavy water falls and is conducted back to the boiler. In the process of being heated from 32 degrees Fahr. (freezing point), to 212 degrees (the boiling point) water increases in volume considerably.

FIG. 99.

A brief consideration of the above figure, and the system it illustrates, will plainly point out the necessity for two important conditions in the arrangement of all such heating apparatus, viz.: (1) that there must be a *rise*, more or less, from the boiler into the first set of pipes, and (2) that the latter should be fixed with a gentle upward inclination in the "flow" from the boiler to the farthest point, and a corresponding *fall* in the "return" from the latter back to the boiler. As a matter of fact, these two points are of the greatest importance, under all ordinary circumstances; with a deep boiler in proportion to its size the flow *may* run into the pipes on a level (see Fig. 100) and the circulation will still be maintained, and with a short length of piping only, these may also be laid on a dead level, and the water will circulate properly (especially if the "flow" pipe is fixed above the "return," instead of on the same level). But long lengths of piping must be given a moderate but regular upward inclination from the boiler. As little as 4in. of rise in 100ft., or 1in. in 20ft. to 25ft., will suffice to enable the water to circulate freely, but 5in. or 6in. per 100ft. is better, and should be allowed wherever possible.

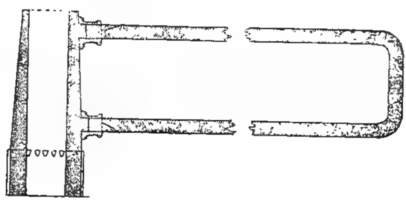


FIG. 100.

Again, the greater the rise from the boiler into the pipes the better. A boiler placed several feet below the level of the pipes will work much better, and the water will circulate more rapidly in the pipes than where the difference is only a few inches. In practice, however, a rise of from 1ft. to 2ft. is sufficient, and answers well.

In arranging and fixing the pipes there ought not to be any sudden *dips* in the flow, nor any *rises* in the return—the gradients must be easy and regular if the water is to circulate freely and rapidly; these points are naturally of greater importance in large and complicated systems of heating than in comparatively small and simple ones. I have known a "flow" to be fixed thus :  (in order to avoid the pipes crossing the pathways), but though there was a circulation, it was very slow and uncertain, and the result very unsatisfactory. Such "dips' in a return would be somewhat less injurious, and a "rise" or arch at some point in a "flow"—as over a doorway or the like—would interfere very slightly with the current, though the fewer of such irregularities in level there are the better.

There are a good many different ways of arranging or disposing the pipes in a house, differing more or less according to the size and character of the structure, their number, the temperature required to be maintained, the lie of the ground, and so forth. In all such systems of heating the skill of the engineer will be displayed in the adoption of the method that is at once the best and simplest possible under the peculiar circumstances of the case. All unnecessary complications must be studiously avoided, and the more simple and straightforward the arrangement throughout, and the fewer angles, elbows, changes of level, etc., the better and more economical will the whole prove in working. If the levels are carefully adjusted, and the natural tendency of the heated water to fly to the highest point is duly considered, the matter will usually be found by no means a difficult one, and a satisfactory result easily arrived at. The different descriptions of boilers in use are now somewhat numerous, and the usual sizes of piping are the 2in., 3in., and 4in., but both will be treated of more fully farther on.

The two most simple arrangements are the plain circuit

(Fig. 101), and the ordinary flow and return, with single pipes (Fig. 102). In both of these systems the water is certain to circulate properly, provided that the levels are correct and the pipes kept full of water. The first method is frequently employed for heating span-roofed houses of

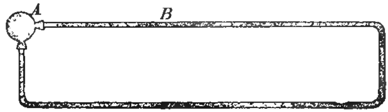


FIG. 101.

small to moderate size, from which frost only has to be excluded, when a single ring of 3in. or 4in. piping will suffice. In such a case the best place for the boiler (A) is at the end where the door is, between it and the corner of the house, as shown, so that the connection may be fixed directly from the boiler into the flow pipe B. The row of pipes is taken right round the structure, close to the eaves or wall-plate, and the return is led down beneath the pathway, close to the door, and into the boiler again at the bottom.

The other method (Fig. 102), is more suitable for a narrow lean-to or three-quarter span structure, where a couple of rows of 3in. or 4in. pipes fixed along the front of the house, either above the bed or stage, or below the latter, will afford sufficient heat for many purposes. If a rather higher

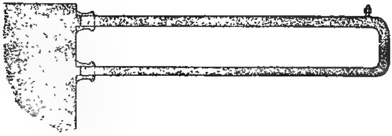


FIG. 102.

temperature is required, *three* rows of piping may be employed instead of two only (see Fig. 103), and in this case there should be *one* flow and two returns, as shown.

Wherever three rows of piping are placed together they should be arranged in a similar manner, for this reason, that with a *single* flow pipe the hot water is carried much more quickly to the farther end of the house than in a double one, while the current flows back more slowly and easily through the double return pipes, and the heat is consequently more evenly distributed than it could be with a double flow and single return, though this plan is not infrequently adopted.

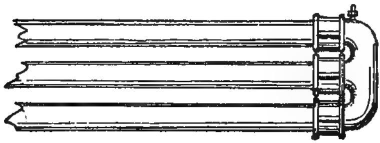


FIG. 103.

In houses of moderate width it is an excellent plan to carry the single flow pipe along the front or near the outside wall, and the single or double return in or near the pathway at the back of the bed or stage, 3ft., 4ft., or possibly a little farther still from the first. In heating a span-roofed structure of considerable size, all that is necessary is to double this system, placing one set on each side, as shown in Fig. 104, where the two returns are shown fixed one above the other on one side of the house, and side by side on the other. Of course, in such a case there must be two separate connections from the main flow pipe, each being fitted with a valve to open or close the current at will.

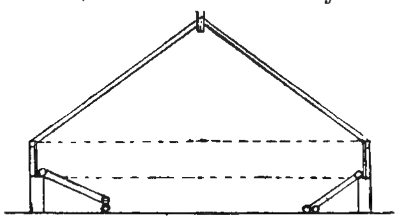


FIG. 104.

The flow-pipe, or pipes, should always be fixed along the outside of the house, near the glass, this being the point where the heat is chiefly required, in order to exclude frost, etc. The old-fashioned plan of placing all, or nearly all, the piping in the pathways or centre of the house is now quite obsolete, as it has been conclusively demonstrated that it is at once much easier, more economical, and better in every way to keep the cold *out* by heating the layer of air next the glass, than to warm the house from the interior, *outwards.* A current of warmed air constantly passing upwards from a hot pipe, just within the glass, effectually excludes all frost or cold, etc., and then the interior of the structure will be warm also, though in all houses of considerable width it is advisable to place two or more rows of piping—usually returns—along the body of the structure, at some distance from the sides. Even in stoves and forcing or propagating-houses, where there is plenty of bottom—as well as top—heat in the body of the house, it is a capital plan to run a 2in. pipe—a flow if possible—along just inside the eaves, near the wall-plate, as shown in Fig. 105. This will effectually prevent the ingress of anything like cold, even in the severest weather, and ensure a genial temperature at all times, but a valve or valves should be provided to enable the current to be cut off in mild weather, when less heat is required.

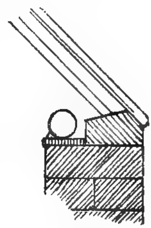


FIG. 105.

In heating narrow span-roofed houses—of say 12ft. or less in width—a very common method is to run a 3in. or 4in. flow along each side, near the eaves, and a return of the same size down each side of the central pathway, as shown in Fig. 106. In a large nursery in Kent, where the houses, each 100ft. by 12ft., may be counted by the score, nearly the whole are heated by means of a single 2in. flow along each side, with a 4in. return to each, placed low down in the pathway, near the ground. With plenty of boiler-power even this small amount of piping suffices to maintain a genial temperature, sufficient for any of the usual run of greenhouse plants, in almost any weather.

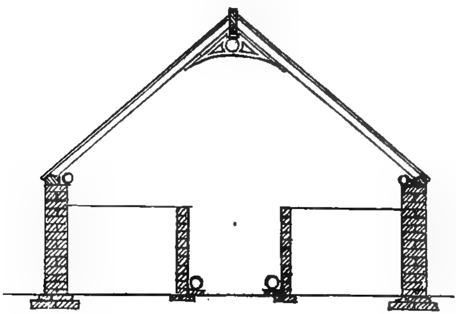


FIG. 106.

But in wide structures, where a high temperature has to be maintained, it may be necessary to have four, six, or even eight rows of piping on each side. Cases in which as many as *sixteen* rows of 4in. piping have been fixed in market-growers' forcing-houses, from 12ft. to 15ft. in width only, have come under my notice; in such cases they are usually placed under the (raised) staging, in double sets of one flow and two or three returns, on each side, or in part beneath covered beds (for bottom-heat), and partly exposed. The *best* arrangement of the pipes depends of course upon the purpose for which the structure is required. If intended for forcing, propagating, etc., a portion are usually placed in hollow chambers beneath the bed, or beds, to provide bottom-heat, the rest being disposed in various ways outside, in order to afford the top or air-warmth. But this part of the subject will be dealt with a little farther on.

To return to the plain circuit system. Where one row of piping is not sufficient it may be doubled, putting in a flow and return all round, or along three or even two sides of the house only, with an ordinary syphon (see Fig. 145) connecting the two at the farthest end, where also an air-pipe .must be fixed. In some cases three rows of piping—a flow and two returns—may be carried round three or four sides of a house, with a three-way syphon at the end. But, as evident, this system is only applicable to houses with a door at one end only, as the pipes must pass across the farther end. The system of piping each side of a house of any magnitude separately is therefore usually adopted, and rightly so, especially where the structure is of considerable length, say 50ft. or more.

Most green- or plant-houses are heated from one end, for obvious reasons, and when two or more structures are built contiguous, or adjoining, either end to end or side by side, the boiler and furnace are properly placed at the junction, or in the latter case at any convenient point between or near the ends, in order that the current may be conducted into the different houses as directly and nearly as possible. Valves must of course be placed on the (flow) connections into each house, or set of pipes, to enable the current to be cut off from or turned on to any of them at will, but it is only really necessary to have *one* valve to each set of pipes, this being placed preferably on the flow, all that is necessary for this purpose being merely to stop the current. But in order to enable the pipes in any one structure to be emptied at will, for repairs, or the like, it is necessary to provide tight screw-down or steam-valves on both the flow and return connections. Unlike the ordinary throttle-valves, these are water-tight, but they are of course somewhat more expensive.

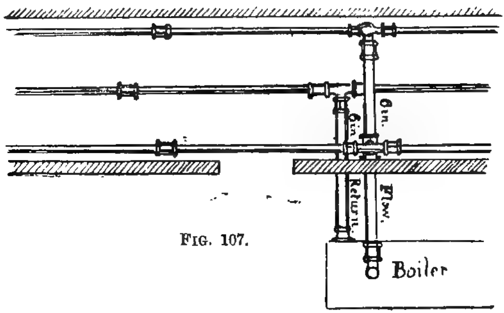


FIG. 107.

Very long houses, or ranges, are however best heated from the centre, or middle, the heating pipes, flow and return, branching off right and left from the mains running across the structure from the boiler. A 4in. pipe will "carry" all right a distance of 200ft. or 250ft., or somewhat farther still if laid with a free rise to and fall from the farther end, but houses of 500ft. or more in length are best heated from a boiler or boilers placed at or near the middle, the pipes branching off right and left to each end. In such a case it is usual to employ 6in. mains to and from the boiler. See Fig. 107.

Where several houses are built adjoining (side by side), and have to be heated from one boiler, or rather stoke-hole, the best plan is to run two mains, flow and return, from the boiler across the ends of the houses, and by preference *inside* them, in a shallow brick pit or trench, so that there may be no loss of heat. On these mains T-pieces

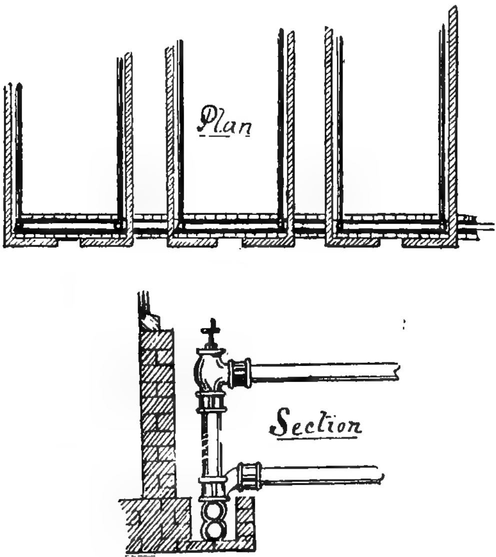


FIG. 108.

are fixed where required, that is opposite the flow and return (heating) pipes, on the two mains respectively, these being connected on and each fitted with a valve. Of course there will be a rise from the mains into the heating pipes, so that the former may run beneath the doorways or paths, etc., and this also ensures a proper circulation of the water in the right direction. A general idea of such a system may be gathered from Fig. 108.

In some few instances it is found impossible to get the boiler down sufficiently below the level of the pipes, owing to water being found at a short distance below the surface. Methods of surmounting this difficulty are described under the heading of stoke-holes (p. 215), but supposing it to be found impossible, or inadvisable, to construct a water-tight hole, the only alternatives are to employ a boiler of shallow construction, such as the form of the Champion (tubular) boiler (made by the Thames Bank Iron Co.), the "Reliance" boiler (Templeman's patent), which is illustrated in Fig. 130, or something of the kind, with only a very slight rise out of the crown of the boiler into the pipes, such as that afforded by an ordinary elbow. I have both seen and had to use saddle and other horizontal boilers made with the flow connection issuing from one *end* or *side* of the crown, on *the level*, without any rise at all into the pipes, but though this may answer in the case of a deep or vertical type of boiler, I can, from experience, strongly advise the avoidance of any such arrangement, owing to the extreme slowness of the current, and the generally unsatisfactory results obtained.

But where, from any cause, the boilers cannot be sunk deeply enough, and even the shallowest make is inadmissible, the only way out of the difficulty is to heat from a higher level, on what may be termed the "return" system of heating. In this the boiler is fixed as low down as can be conveniently done, and the flow is led from it almost directly into a raised tank, or circulating cistern, elevated 3ft. or more above the level of the pipes. From the bottom of this tank another pipe leads downwards again into the heating pipes, which must all be laid with a gentle *downward* inclination to the point where the return re-enters the boiler. If carefully carried out this method answers fairly well, though as there is naturally some loss of heat in the circulating cistern, etc., the results are scarcely as economical and effective as under the usual system. A simple arrangement of this kind is illustrated in Fig. 109.

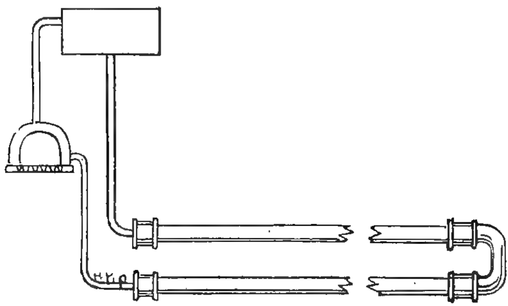


FIG. 109.

Every hot-water apparatus must be provided with a feed-cistern, as well as with one or more air-pipes, or cocks. The former is used for filling the pipes, etc., and it also allows for the expansion and contraction of the water. The air-pipes, which permit of any confined air or steam passing out of the heating pipes, and thus enabling them to become quite filled with water, must be fixed at all the highest points in the pipes where there is no other outlet. They are preferable to cocks as being always in action, while the latter have to be opened to allow the confined air, etc., to escape, and then closed again. An air-pipe usually consists of a small brass union screwed into a hole drilled in the top of the pipe, at the highest point, with a few feet of iron or compo. tubing of small diameter attached, the $\frac{3}{8}$in. or $\frac{1}{2}$in. size being generally employed. The top of this pipe, which should be carried up in a corner or other convenient place, and secured by holdfasts, must be rather higher than the top of the feed-cistern, so as to prevent any overflow when the latter is full.

The position of the feed-cistern is not a matter of any great importance, but it is usually, and best, connected with the return pipe close to the boiler. It ought to be elevated well above the highest point in the pipes, anything from 2ft. to 10ft. above them being suitable. It may be fixed on a high staging, or shelf, in any convenient place, either inside the house, or in the stoke-hole (if this is covered in), but not out in the open air, as sometimes seen, where it is liable to become frozen in severe weather. It should contain at least two or three gallons to each 100ft. run of 4in. piping, to allow for the expansion and contraction of the water as it becomes heated and cooled again. The connecting pipe ought not to be less than $\frac{3}{4}$in. diameter even for a small apparatus, and for a large one should be from 1in. to 2in. in diameter.

When fixing large and powerful boilers, especially those of the tubular types, which heat quickly and create a rapid and powerful current in the pipes, it is at once usual and highly advisable to place a vertical stand-pipe, several feet in height, and open at the top, on the flow connection close to the boiler. This acts as a kind of safety-valve, relieving the pressure caused by any sudden rush of water or steam from the boiler, and preventing the unpleasant and injurious "kicking" noise often experienced in such cases, as well as allowing any confined air or steam to escape instead of being driven into the pipes.

The pipes are frequently laid on proper chairs, formed of cast-iron (see A in Fig. 110), and these are sometimes fitted with rollers, as at B in the illustration, to allow of the pipes moving easily as they expand, but in market-growers' houses they are usually supported by means of brick piers of the requisite height, placed here and there—generally one to each (9ft.) length—and these are found to answer the purpose quite sufficiently well. The bricks must, however, be laid on a firm bottom, and bedded in cement rather than mortar.

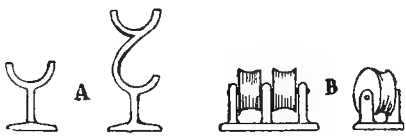


FIG. 110.

Amount of Piping Required for Different Temperatures.—Structures in which a comparatively high temperature has to be maintained, must, naturally, be fitted with more piping, in proportion to their size, than houses from which frost is to be excluded only, or where nothing more than a cool greenhouse temperature is required.

A good many rules have been formulated, from time to time, and by various authorities and writers, for ascertaining the amount of piping necessary to afford temperatures suitable for different purposes. Of these some are altogether too complicated, and others totally absurd, while even that standard authority, Hood, only gives a table showing the amount of piping required to heat given quantities of air *per minute*—a totally different thing from merely *maintaining* a certain temperature in a structure of any kind, and consequently quite useless for the purpose under consideration.

Decidedly the most practical and reliable rule—like nearly all other good things, a simple one—is as follows: Multiply the length of the structure by the width, and the result by the *average* height (this being easily obtained, in most cases, by adding the greatest and least heights and dividing by two). This gives the actual cubic contents of the house, in feet, and this, divided by 30, shows the number of feet of 4in. piping necessary to thoroughly exclude frost (under ordinary circumstances) and maintain the usual greenhouse temperature suitable for plant-houses, cool conservatories, late vineries, etc.; divided by 20, the above product gives the required amount of similar piping for what are termed intermediate houses, cool stoves, early vineries, etc.; by 15 that for ordinary stoves or hot-houses; and by 10 that required for forcing and propagating-houses, East Indian orchid-houses, and other structures in which a high temperature (65° to 70°), has to be maintained in any weather. Stated in a somewhat different way, but amounting to much the same thing, 30ft. to 40ft. run of 4in. piping must be allowed to each 1000ft. of cubic contents for greenhouses, conservatories, and other cool structures; 50ft. per 1000 for a warm greenhouse, "intermediate" house, or early vinery; 60ft. to 80ft. for stoves, and 80ft. to 100ft. for forcing houses.

The most generally employed, and best size of piping for all ordinary purposes is the 4in. (*internal* diameter). This gauge contains a greater bulk of water in proportion to its diameter than any smaller sizes, and consequently retains its heat longer, while pipes of this size of course "carry" considerably farther than anything smaller. The 3in. and 2in. sizes are chiefly employed for connections, etc., or as heating pipes in small houses, or for outside rows in those of moderate size (see p. 160). The circumference of a pipe of any size being always in the same proportion to the diameter (roughly speaking, as 3 to 1), a foot of 2in. piping affords as nearly as possible half the heating surface of a foot of the 4in. gauge, or half a square foot and one square foot respectively, while the 3in. size gives three-quarters of a foot, three rows of this gauge affording rather more actual heating surface than two rows of 4in., or as 9 : 8.

In all cases it is advisable to allow rather more piping than is really necessary for the purpose in view, both in order to avoid having to make the pipes very hot at any time (this being considered injurious), and also to enable a somewhat higher temperature to be afforded, should such be necessary at any time. For the same reason the boiler also ought always to be well *above* its *work*, rather than below it, having to force the fire in severe weather being at once a wasteful and dangerous proceeding. The temperature of the pipes in any low-pressure hot-water apparatus cannot rise above 212°—the point at which water boils—and any farther access of heat is carried off in steam, but even this point ought seldom or never to be reached, a temperature of 160° to 180° being safer and better than a higher range, especially where delicate ferns, etc., are cultivated, very hot pipes having the effect of unduly dessicating and scorching the air.

It must be borne in mind that the aspect and position of a greenhouse of any kind, as well as its construction, and the local climate, all have their effect on the average temperature, and ought to be taken into consideration when calculating the amount of piping required. A house, or houses, of whatever class, built on a warm southern slope fully exposed to the sun, and sheltered on the north and east, will not require so much artificial heat as another standing on very bleak or open ground, or in a comparatively low, damp, or sunless spot, in order to secure the same temperature. Climate also varies considerably, that of most places as far north as Yorkshire or Lancashire being naturally much colder than the average of Devonshire or Cornwall, especially near the coast, where frost never appears to penetrate or possess so much power as in inland localities. But in all cases it is wise to be on the safe side, and provide rather more piping and heating power generally than is actually necessary rather than too little.

Lastly, unless the air can circulate freely round the heating pipes in all directions they cannot radiate their warmth as freely as they would otherwise do. Thus pipes confined in a trench or pit cannot be reckoned as equally effective with those standing free all round, whether covered with a grating or not. Indeed, something like 50 per cent. should be allowed in such cases. Pipes ought never to be buried in the soil, even partially, for where this is done they cannot radiate properly. Never bury iron pipes in ashes, the acid and sulphur they contain eating into the metal and quickly destroying them.

FIG. 111.

The Pipes and How to Fix Them.—As previously stated, hot-water pipes are cast in three sizes, viz., 2in., 3in., and 4in. in diameter, internally. Pipes 5in. and 6in. in diameter are occasionally used to a small extent, but chiefly for the connections, etc., of large apparatus. For any smaller sizes, or fittings, etc., than 2in., wrought-iron tubing, commonly known as "gas-barrel," is employed,

FIG. 112.

this also being made in several sizes, from $\frac{1}{4}$in. to 2in. in diameter, and fitted together by means of sockets and screw threads run on inside and outside. The 3in. and 4in. pipes are usually cast in 9ft. lengths, and the 2in. size in 6ft. lengths, each with a socket on one end, as shown in Fig. 111. Any shorter or odd lengths are obtained by cutting, and when two blank or "spigot" ends have to be joined, a "loose collar" (A), or double socket (B), as in Fig. 112, is employed. A cast-iron pipe is easily cut by nicking it all round with the corner of a flat or triangular file, going a full $\frac{1}{8}$in. deep. Then with a cold chisel and hammer go all round in the nick, striking smartly but not too heavily, and it will presently crack off at the "nick." Pipes of the best quality cut more easily than common or cheap ones, which are usually made of very hard and imperfectly smelted metal. A tool known as a pipe-cutter is used by fitters, and saves a great deal of time and labour. It consists of five or six hard steel discs or wheels, with cutting edges, carried in a kind of short steel chain, with double links, and a handle and thumb-screw to tighten it up. The chain and wheels are passed round the pipe, hitched and tightened up and then worked round several times by means of the lever, tightening up the wheels occasionally so as to keep them cutting. When a good deep cut has been made the cutter is taken off, and a few taps with the hammer and chisel causes the pipe to drop apart.

Socket-pipes, as shown in Fig. 111, are usually employed for heating, especially by nurserymen and market-growers generally, though in some cases the "expansion-joint" and other kinds of piping (to be described presently), are used, but chiefly in small or amateur's houses. The joints of socket-pipes may be made in several ways, the old-fashioned method being to pack each joint well with rope-yarn and a mixture of red and white lead, with a little oil, letting the whole "set" well before using. But this is a far too slow and troublesome process for the present day, while such joints are also very apt to leak, so that this need not be considered farther. An iron cement or "rust-joint," composed of iron filings, sal-ammoniac, and water, with a little sulphur, was much employed at one time, but though very lasting, and usually tight, the rust eating into the metal and joining the pipes immoveably in time, such joints frequently "weep" a good deal at first, and after a time frequently split the sockets, as the mixture expands considerably in rusting.

India-rubber rings have also been much used and recommended for jointing pipes, but though very useful and easily fixed when they fit all right, and the pipes and sockets are uniform in size, great difficulty is often experienced in forcing them into small sockets at all. In fact, I have known two or three men to "shove" the end of a house out bodily trying to get a ring in. Even when in, they sometimes leak, and after a few years the heat renders the rubber hard and perished, and then it cracks and leaks. On this account the joints are frequently filled up with Portland cement above the rings.

But decidedly the best and most lasting joints for socket-pipes, at least in the writer's considerable experience, are those made with pure Portland cement alone. This material is very easily mixed and applied, while it hardens or "sets" almost immediately, and if properly done will last a lifetime, if not for ever. Even if it is ever desired to take the pipes apart, all that is necessary is to break through the hard face of the cement with a narrow steel chisel, wriggle the pipes about a little, and away they come, totally uninjured.

The sockets should be packed about half full of rope-yarn first—indeed, 1in. to 1½in. of cement is sufficient, provided that it is quite fresh and "quick," as it must invariably be for all work of this kind. Pack the yarn in tightly with a proper caulking-iron (see Fig. 113) and hammer, and then fill up with the cement, freshly mixed with water

FIG. 113.

to the consistence of mortar, working it in well all round with the blunt end of a bit of lath, or the like, and finally smooth it off neatly with the fingers, or a small pointing trowel. Good fresh cement will set quite hard in about an hour—less in hot weather—and will practically last for ever. We generally go over the joints a second time about ten minutes afterwards, making good any faults and finishing off well and neatly. Should any "weep" a little when the pipes are filled, throw a little fresh, dry cement on repeatedly, and it will probably cease as the water becomes hot. Should any leak badly, better draw off the water, cut out the cement, and re-make the joint.

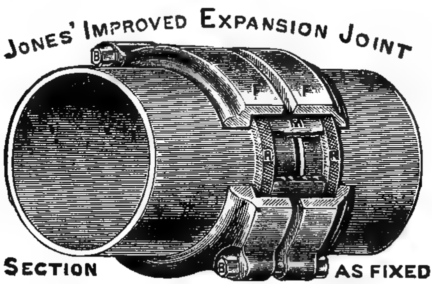


FIG. 114.

The "expansion-joint" pipes are cast with a small socket and narrow flange at one end, with two "lugs" slotted or bored to receive the shanks of a couple of short bolts and nuts. A loose collar is also provided to slip over the spigot end of the next pipe, with a projecting ring and two lugs to correspond with those on the flange of the pipe. An indiarubber ring is passed round the spigot end of the next pipe, about an inch from the end, with the loose collar behind it, and this is then pushed into the socket of the other pipe, and the india-rubber ring is then compressed by tightening up the nuts until it grips the inner pipe tightly. This works all right when the nuts run easily on the bolts, but when they work stiffly they are a nuisance, and in any case the cement joints can be made both better and more quickly.

FIG 115.

Fig. 114 shows Jones' Improved Expansion joint, which possesses several advantages over the old or ordinary form.

Ordinary flange-pipes are not much employed in hot-water work, though there is no reason why they should not be, as they would answer the purpose quite as well as any other description. The expansion and contraction has to be reckoned with, of course, though this difficulty is easily surmounted by using chairs with rollers, and in any case it is no worse than that taking place where socket-pipes are used.

The pipes should always be laid as far as possible *with* the current; that is to say, so that this discharges from a spigot end into a socket, or with the socket of each length at the back or lower end, at any rate in the case of flow pipes. This is not, of course, absolutely indispensable, as the water will flow almost as well one way as the other, but it is the ***right*** way, and should be followed whenever practicable (see Fig. 115).

Before commencing to caulk the pipes up, take care that each spigot end is pushed quite "home" in its socket, otherwise the rope-yarn, or whatever kind of packing is employed, may become forced over the end, and interfere with the current. Caulking renders the pipes comparatively firm and steady, and when finished the whole ought to be gone over carefully with the spirit-level for the last time, before putting in the cement.

When a length of piping of any size has to pass into one of a larger gauge, or *vice-versa*, what are termed *reducing* sockets are usually employed. In high-class work these are indispensable at certain points, but for rough jobs, or where the pipes are out of sight, as beneath beds and stages, we never trouble to use them, but just run the ends of the smaller pipe well into the larger (whether socket or spigot end is immaterial), packing it round well with rope-yarn—a firm collar may be made by binding tightly round the smaller pipe, near the end, with this—and then filling up with fresh cement, into which some small pieces of broken brick are pressed. In some cases a collar of wood or stout leather is used, but however managed, this makes a sound and safe joint, if properly done, even where a 2in. pipe is thrust into a 4in. one. In fact, one can do almost anything in the way of jointing pipes, whether of iron or earthenware, with this invaluable material. I have made over fifty cement joints with it in quite a small but rather complicated apparatus, in which all sorts of odds and ends of piping were employed, and not one of them even wept a drop at the first trial.

When fixing a number of lengths of piping, with connections, etc., the best way is to lay and roughly level them first; then caulk up the joints, which brings each into its exact position. Then go over them again very carefully with the spirit-level, and finally "make" the joints, after which they must not be disturbed in any way until the cement has set thoroughly. Fittings, or connections, such as elbows, T-pieces, etc., frequently require to be supported in place by means of blocks, etc., until the joints are made and the cement is set, when the supports may be gently removed.

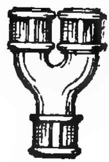


FIG. 116.

Where the currents in two pipes have to be joined together and carried in one, what is termed an "outlet syphon" (see Fig. 116) is usually employed, or in some cases a branch-piece (Fig. 117) is preferable, but if the affluent joins at right angles, an ordinary T will be best, naturally. Again, when running from a single pipe (say a flow) into *two* others (as returns), if these are placed one over the other, branch-pieces should be employed at each end, as shown in Fig. 118, instead of outlet syphons, which would render the current unequal, but if placed side by side the syphons will answer best.

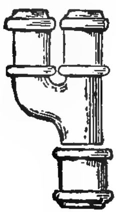


FIG. 117.

Boilers.—There are now a considerable number of boilers—or to speak more correctly, *heaters*, their purpose being merely to *heat* the water as it passes through them, and not to *boil* it—of various kinds on the market, all of which possess their good and bad points, while most of them are more or less suitable for different purposes. The majority are made in various sizes, according to the amount of piping they are intended to heat, but some forms are better suited for large quantities of piping, and others for smaller lengths.

The best "boilers" are made of stout sheets of wrought-iron, welded or rivetted together, the usual thicknesses employed being $\frac{5}{16}$in. and $\frac{3}{8}$in. Cast-iron boilers are also employed to some extent, but though these are at once much less expensive, and resist the combined action of fire and water better than the wrought metal, they

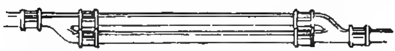


FIG. 118.

are unfortunately liable to crack at any time. This usually occurs in frosty weather, particularly if the furnace door is opened suddenly, though it may take place without any apparent cause, and occasionally happens the very first time the fire is lit. Hence they are scarcely dependable enough for work of any importance or magnitude, though at the same time a cast-iron boiler will frequently last and do excellent work for the best part of a lifetime.

The saddle-shaped boiler is one of the most popular and useful types for all ordinary purposes, and for heating lengths of from 100ft. or 200ft. to as many thousand feet of 4in. piping either a plain saddle or one of the rather numerous forms of this boiler can scarcely be beaten.

Saddle-boilers are made in both wrought and cast iron, and those of the former class may be had either welded or rivetted.

Boilers of the horizontal tubular type are now extensively employed by market gardeners and nurserymen for heating long ranges of piping. These consist chiefly of cast-iron pipes, but in this form the metal is not nearly liable to give way suddenly as in large castings, besides which these boilers are now so constructed as to enable a defective tube to be removed and replaced in a very short time and with comparatively little trouble.

But even where these, or indeed any boilers of large size are employed for important work, it is always advisable to fix them in pairs or trios, connected together with valves, etc., so that either or both can be put to work the whole of the piping, or be disconnected entirely at any time, for repairs or the like, without affecting the temperature of the houses to any extent. Thus, supposing there is say 2,500ft. of piping to be heated, if only one boiler is put in this ought to be capable of working at least 3,000ft., but instead of this it is much better and safer to fix *two*, each sufficiently powerful to heat 2000ft. or so. Then, in mild weather, when less heat is required, or one or two houses may be cut off, either boiler will do the work alone, while when coupled together they will maintain the maximum temperature in severe weather easily. Lastly, should one break down, the other will suffice to maintain at any rate a moderate temperature while the other is being repaired or replaced.

The heating power of all hot-water boilers is calculated by reckoning the number of square feet of surface exposed directly to the fire, and to each square foot of such surface allowing 50ft. run of 4in. piping. But as few if any boilers will heat this quantity properly except under the most favourable conditions all round, this estimate, which is known by engineers as the *approximate* heating power, is practically excessive, and not more than about two-thirds of this amount of piping, or about 32ft. instead of 50ft., to each square foot of boiler surface, can be safely allowed. This is termed by engineers the *actual* heating power. And even then the boiler ought in all cases to be well above its work.

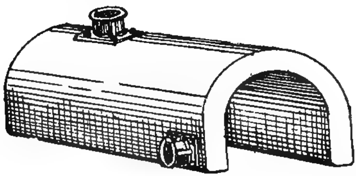


FIG. 119.

The plain saddle is a very favourite type of boiler, and for heating moderate lengths of piping, say from 150ft. to about 1200ft., is still one of the best and most effective. This boiler, which is made in various sizes from 18in. in length by 10in. by 11in. (inside the arch) up to 5ft. or 6ft. in length, and proportionately wide and deep, is shown in Fig. 119. If properly set this boiler is fairly economical in fuel, as well as easily managed, and the construction being quite simple, they cannot well get out of order. This class of boiler will also consume almost anything in the way of fuel; coke in moderate sized pieces, or anthracite coal, should be used when the full heat is required, but for banking up at night, and on warm days, cinders, dusty coke or coal, etc., may be freely employed.

The setting of all boilers of this type is a matter of the greatest importance, often making all the difference between economy and extravagance in fuel—between efficient and non-efficient working. This ought consequently never to be left to ignorant or inexperienced persons. The best method of setting most of the forms of saddle boilers is shown in Fig. 120. Flues situated on the top or crown of a boiler are comparatively ineffectual and useless, as heat strikes downwards to a very limited degree only; such should therefore be avoided as far as possible, or if employed at all, only to carry the nearly

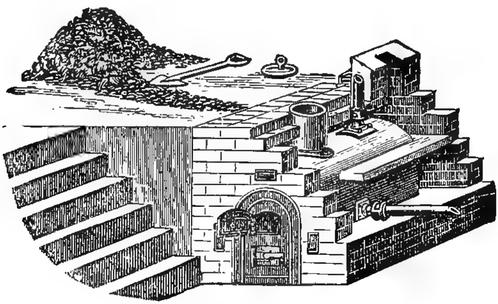


FIG. 120.

spent fumes, etc., back to the chimney the last time. In all cases the endeavour should be to keep the current of heated air, or escape, as *low down* as possible, after leaving the fire; in fact, if a decided dip can be arranged at some point between the fire and the chimney there will be a considerable gain in heating power and general efficiency. This may usually be effected by fixing a vertical "mid-feather," or diaphragm in each of the side-flues, about half-way between the front and back of the boiler, as shown in the illustration. Horizontal mid-feathers are also sometimes used.

A form of saddle boiler with waterway end or back is sometimes adopted, an opening being left in the upper part of the back to allow the flames, etc., to pass into the flues. This form is illustrated in Fig. 121.

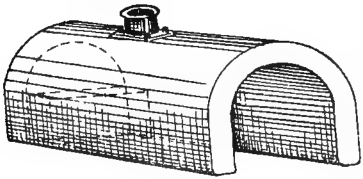


FIG. 121.

Another and really excellent type of saddle boiler is provided with a waterway end, with two oval openings in the sides, at the far end, and about half-way up the boiler, leading into the flues. These are usually made in cast-iron only. I had one under my care at one time that did really splendid work, heating several hundred feet of 4in. piping—a heavy load in proportion to its size—quite easily and well, with a small consumption of fuel and very little care. This boiler, which is known as Jones' patent, is illustrated in Fig. 122.

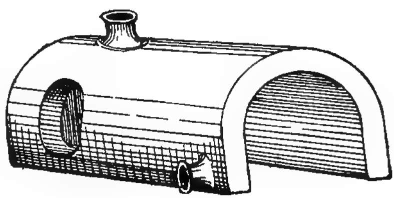


FIG. 122.

The next type of saddle boiler to be considered is the "terminal-end and flued," which is also known as the Chatsworth boiler. This is similar in form to an ordinary saddle, though usually made somewhat flatter at the top and sides, but the crown is considerably deeper than usual, and a wide, flat flue is brought through this from the back of the furnace arch to the front again. This boiler is illustrated in Fig. 123, and may be employed to heat from about 500ft. to 2,000ft. of 4in. piping. When properly set it is a very powerful and economical boiler, but if the flues are so arranged that the draught passes from the front end of the flue in the crown directly back over the top of the boiler it will be found very extravagant in fuel and little, if any, more powerful than an ordinary saddle. Instead, it should be set with a deep, but narrow, flue on each side, with a mid-feather, extending to within about 6in. of the bottom, in each, about half-way along the boiler, as previously described.

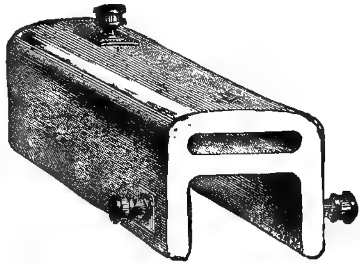


FIG. 123.

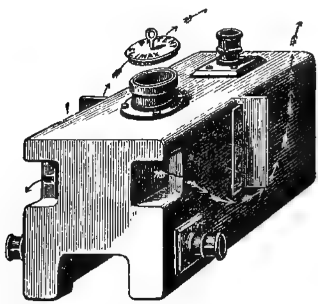


FIG. 124.

The Climax boiler (Fig. 124) is another very powerful form of saddle boiler, and when properly set is one of the best of all this class for lengths of piping up to 2,000ft.

or 3,000ft. Its construction being, however, somewhat complicated, renders it a rather more expensive boiler than some others. It is usually constructed to be fed through the crown, as shown, the fire-door being only used for stoking purposes, cleaning the bars, etc. It is best set as advised above, with narrow return flues and mid-feathers on each side, as shown in the illustration.

The "Gold Medal" or "Express" boiler (Fig. 125) is yet another form of the saddle, but with three flues through the crown instead of two, the draught passing *forward* through the larger central one first, and then returning through the two smaller ones on each side, to the chimney at back. Though a powerful and with some a favourite boiler, we consider this inferior to the Climax, as the flues in the crown being so small require frequent cleaning, while there is not so much surface exposed directly to the fire, and, lastly, without an unusually high chimney to increase the draught the considerable heating surface at the sides is wasted. This fault can be overcome by bringing the draught from the two side-flues in the boiler forward again by means of two other narrow ones, with or without mid-feathers constructed outside it, as shown in Fig. 120. But this

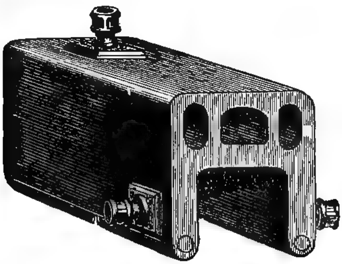


FIG. 125.

necessitates placing the chimney near the front of the boiler, instead of at the back, and as in this case one of the flues must be taken over the top of boiler, this one will probably not draw as well as the other shorter one. Or the two flues may be joined again, and taken back over the top of the boiler to a chimney at the back, but this would render a very high chimney necessary, especially in the case of a long boiler. The Gold Medal boiler will heat from 500ft. to 3,000ft. of 4in. piping.

Both the ordinary saddle and the terminal end and flued boilers are occasionally constructed with an opening in the crown so as to be fed from the top. This saves labour to a certain extent, and enables the furnace to be filled more fully than in the ordinary way, through a fire-door in front.

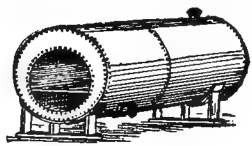


FIG. 126.

A form of saddle boiler known as the L-ended was a good deal in vogue at one time, but is now almost obsolete. It consists of a small saddle boiler of the usual form, connected by means of three short tubes—one from the crown and two at the back, at the bottom—with a large flat L-shaped water-way hood, 4in. or so in thickness, against which the flames and heat from the fire act directly and with great power. This boiler is consequently very rapid in action, as well as powerful, when carefully set, but it does not appear to last for any length of time.

The Trentham, or Cornish boiler (Fig. 126), is a powerful type, suitable for heating large quantities of piping. It is not a quick heating boiler, but when once the water becomes hot it will remain so for a considerable time, even after the fire goes out. This boiler, which is on the whole more suitable for heating public buildings, large churches, etc., than horticultural structures, is sometimes made with a water-way end, and also with cross-tubes, which greatly increase the heating power. The comparatively new class of horizontal tubular boilers

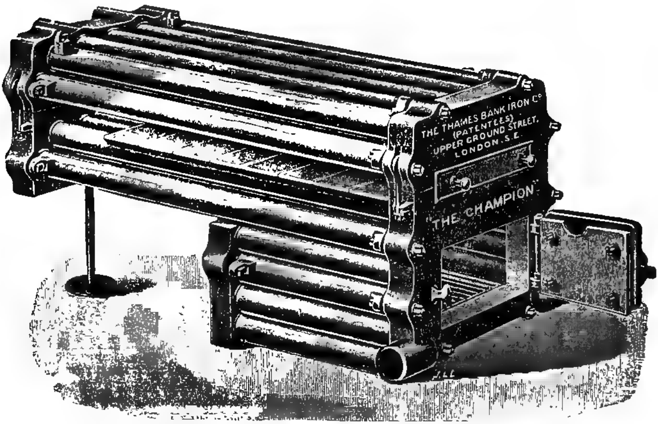


FIG. 127.

have, however, to a great extent displaced this and other allied types, by reason of their greater power and comparatively small cost.

These horizontal tubular boilers are now frequently preferred by many market growers and nurserymen, and where long ranges of piping have to be heated they are probably at once the best and cheapest description of boiler extant. They also heat very quickly, and if properly set and worked are by no means extravagant in fuel—this may at least be truly said of the newer and improved forms, such as the Champion, made by the Thames Bank Iron Co. (see Fig. 127), though some of those first constructed undoubtedly consumed a large amount of fuel in proportion to the amount of work done.

These boilers being entirely constructed in sections, and the tubes being easily removable, have also considerable advantages, as a cracked or faulty tube can be taken out and replaced in a very short time. This class of boiler can also be set in comparatively shallow stoke-holes, and one form with only a single row of pipes over the furnace, though scarcely as economical in working as those in which the draught is taken forward and backward again. A very great improvement in the heating power and general efficiency of this type of boiler has been effected by casting the pipes with a web or feather on each. This, when the pipes are fixed as shown, prevents the heated air, etc., from passing too directly into the chimney, and forces it to travel the whole length of the boiler and back twice or thrice, when it will have parted with the greater part of its caloric. Where, however, special or important work, such as forcing, etc., is carried on it is always advisable to set

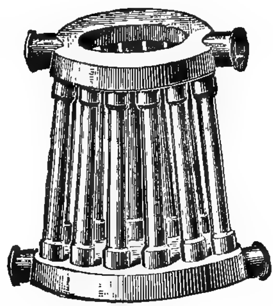


FIG. 128.

these boilers in pairs, with valves, etc., as described on p. 179, so that in case of a breakdown in one, the other can be put on to maintain the heat, in part if not entirely.

The vertical tubular boiler (Fig. 128) is another powerful type, though more suitable for a smaller class of work than the last, while its form also renders it naturally more extravagant in fuel. Fig. 129 shows a small boiler of this type fitted with water-bars.

There are several other forms of what may be termed *fixed* boilers (*i.e.*, such as require to be set in brickwork), but with one or two exceptions it is hardly necessary to refer to them here, as they are scarcely ever employed at the present day, and are indeed almost obsolete.

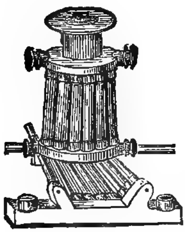


FIG. 129.

A boiler known as Cannell's Circulator may be briefly referred to as one of the exceptions above. In this the draught from the fire, which is placed at the bottom, in an ordinary furnace, is made to traverse a series of wide but very shallow flues arranged between thin layers of "water-way," passing backwards and forwards several times. It is cast in flat sections, each consisting of a water-space and flue-space, with lugs on both sides of each section, both to enable the sections to be bolted together, and to provide a passage for the water to flow from one section to the next. This boiler is, or was, exclusively employed in the large establishment of the inventor at Swanley, but it does not appear to have ever become at all extensively adopted.

A boiler called the "Reliance" (Templeman's patent) is shown in Fig. 130. This is really a form of the saddle, having a pair of return flues running, not through the crown but through the sides, on a level with and not above the furnace. This renders it a very shallow as well as powerful boiler, useful where a deep stoke-hole cannot be provided. This is a favourite boiler with the fruit growers in Guernsey and Jersey, and has proved a thoroughly useful and reliable article. It will heat up to about 1,500ft. of 4in. piping with the best results.

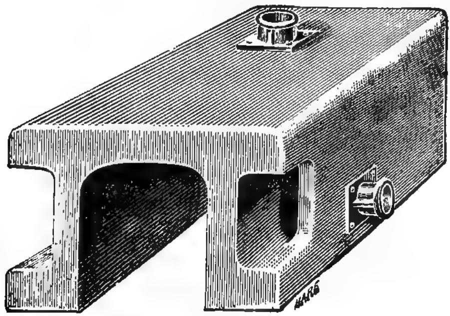


FIG. 130.

Another type of saddle boiler, known as the "Cruciform," is shown in Fig. 134, on p. 194.

The conical or "Cyclops" boiler (see Fig. 131) is a vertical form of heater requiring to be set in brickwork. It consists of a cylindrical casting with a water-jacket all round and the furnace in the centre. It is fed from the top, and the flues are carried round the outside of the boiler, usually by means of mid-feathers, as shown in the illustration. Though a useful boiler for small to moderate lengths of piping, the great height of the larger sizes renders a deep stoke-hole necessary, while it is also not particularly economical in fuel, and in fact is almost out

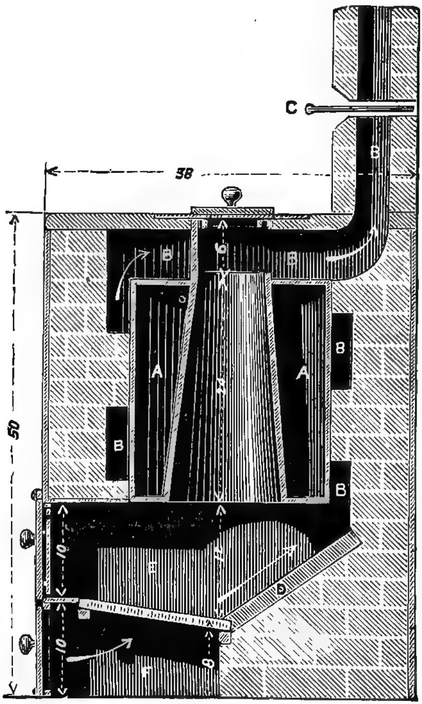


FIG. 131.

of date now. The "Excelsior" is another form of the same thing, but with straight or upright sides (not conical); this is made in wrought iron as well as in cast metal.

The most inexpensive form of boiler of all those requiring to be set in brickwork is the coil, an example of which is shown in Fig. 132. This consists merely of a length of ordinary wrought iron steam tube bent round four or five times into a spiral coil; when heated the water courses rapidly through the coil (within which the fire is situated), in an upward direction of course. This form of boiler is only suitable for heating small quantities of piping of from 50ft. to about 200ft., but when properly set a coil will do good work for several years, though sooner or later they become burnt through at some point, usually near the top. The best way to set a coil boiler is to leave a space of about 1½in. between the outside of the coil and the inside of the brickwork. The upper part of the furnace—that above the base of the boiler (which should be elevated a course or two above the level of the fire-bars)—is most conveniently constructed in a circular form, the bricks being laid end on to the furnace. This part of the furnace should also be made tapering, so as to correspond with the taper in the coil (this is given chiefly to prevent the fuel "hanging" in the coil at any time), and it should be brought in rather sharply just above the last lap, or turn. If set so that the last lap of the coil crosses the exit into the chimney, the pipe will soon burn through at this point, but if set as above it will withstand the action of the fire for several years.

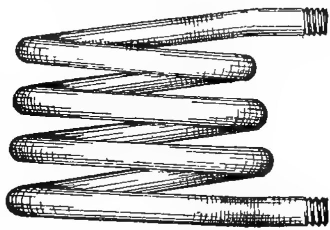


FIG. 132.

A coil of 1in. piping, with four laps, will heat up to 100ft. of 4in. piping easily, and being fed from the top, the fire is easily managed, and will keep alight for eight or ten hours. At the present time, I have one, of 1¼in. tube, which heats 150ft. of 4in. piping, and a house 50ft. by 11ft., capitally, while a double flue, carried from the furnace across one end of the house and back, affords plenty of heat for a covered propagating bed as well. This is a capital plan, especially with boilers of this class, as utilizing a lot of surplus heat that would otherwise pass away up the chimney and be wasted, and rendering the apparatus a fairly economical one, on the whole. Such a coil only costs from 15s. to 20s., or a larger size 25s., so that this is by far the cheapest and best kind of boiler for the working man or mechanic's small greenhouse. Any handy man can set a coil sufficiently well, and only some 500 or 600 of bricks are required.

The circular part of the furnace above the coil may be carried up a foot or more, and this forms a kind of hopper to contain a reserve of fuel; in this case the interior should be rendered as smooth and even as possible. Or a short chimney-pot may be fixed on the top, with a lid, for the same purpose.

We now pass to the class of *independent* boilers, which require no brickwork setting, but merely to be stood on a few loose bricks at any convenient point, and connected on to the pipes. At the same time all such boilers are the better for a casing of brick or some other non-conducting material, which not only conserves the heat, but protects the metal from injury by the weather, etc. Though extremely useful for small structures with lengths of piping up to 100ft. or 200ft., these boilers are unsuitable, as a rule, for any large or heavy work, and are consequently only made in the smaller sizes.

Decidedly the best and most effective of this class of boiler, at any rate for comparatively small quantities of piping, is, in my opinion, that known almost indifferently as the "Gem," "Star," and "Victor" boiler, one of which (with top-feeder) is illustrated in Fig. 133. These consist of a double cylindrical shell, placed 2in. or 3in. apart, and forming a thin circular, vertical water-jacket surrounding the fire, the cylinder being either straight or conical in form, the latter by preference. There is a cover forming a feed-door at the top, with an exit into an iron smoke-pipe, and a set of fire-bars, a small ashpit, and a couple of close sliding doors with one or more regulators, by means of which the draught may be regulated to a nicety, at the bottom. The furnace works on what is known as the "slow combustion" principle, the draught being almost cut off at the bottom when the fire is once well alight, and a steady and regular heat is thus afforded for several hours, until the fire burns low, when it must be replenished, drawn up a little, and the draught again nearly stopped.

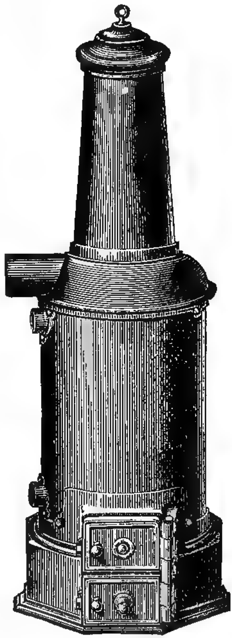


FIG. 133.

Boilers of this class are thus very regular in action, while consuming a comparatively small amount of fuel.

These boilers are made in several sizes, calculated to heat from about 60ft. up to 200ft. or 300ft. of 4in. piping, but the very small sizes are not to be recommended, owing to the small body of fire requiring very frequent attention, and seldom lasting more than four or five hours. The largest sizes, again, are objectionable, owing chiefly to their great height, the most useful being those constructed to heat from 100ft. to 200ft. of piping, and even these ought always to be well above their work. A "top-feeder" to hold extra fuel, is sometimes added to this form of boiler, and enables the fire to be kept alight for some hours longer. As the fuel below is consumed, that in the top-feeder or hopper above drops down and takes its place. Coke broken small — into pieces about the size of hen's eggs—forms much the best fuel for this class of boiler, though they may be banked up with cinders, etc. when the fire is to be kept low for a time. Coal is useless, and even the anthracite does not burn well in these small, close furnaces.

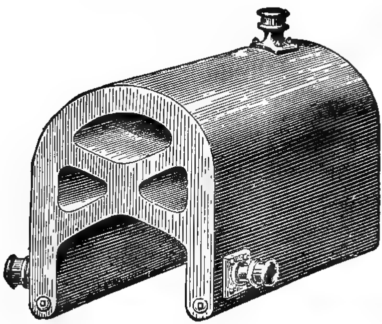


FIG. 134.

No stoke-hole, or only a very shallow one, is required for these boilers, as a rule, as the flow connection may pass directly into the heating pipes, and with the levels properly adjusted, they will work well. At the same time it is as well to afford a slight rise from the boiler into the pipes, if only 6in. or 8in., by dropping the former a little.

A very excellent and effective form of these independent cylindrical boilers, and the *best* of the entire class where a more powerful article than those just described is required, is the dome-top boiler, shown in Fig. 135. This is constructed on very similar lines to the "Star" boiler, but the top, instead of being flat, with a feed-door, etc., is made into a dome-shaped waterway, the inner surface of which presents a large and highly effective heating surface to the fire. The feed-door is removed to the front, as shown in the sketch, the exit into chimney being placed at the back some little distance below the crown of the dome. So much more does the dome, etc. add to the heating power of this boiler, that

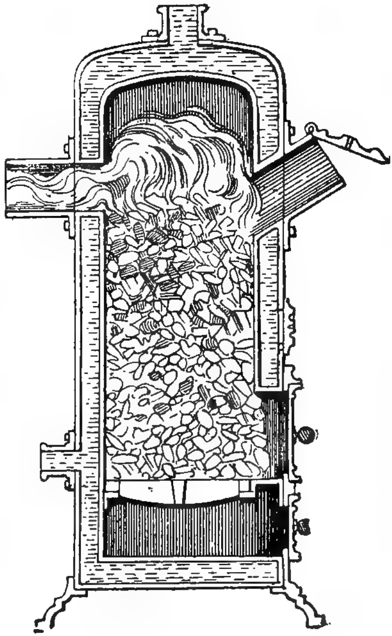


FIG. 135.

whereas a "Star" boiler 36in. in height will only heat about 200ft. of 4in. piping properly, a "dome-top" of the same height will do something like 450ft. The flow socket is placed on the top of the dome, and the return, or returns, at the bottom, at the back, or on one or both sides. This boiler is constructed to heat from about 150ft. up to fully 1,000ft. of 4in. piping, but I should scarcely recommend this form where more than about 500ft. or 600ft. have to be heated.

Another form of these upright cylindrical boilers consists of a double cylinder of sheet iron in the upper part, and a small coil, similar to those previously described, fixed in the lower part, with the fire inside it. Though useful for heating very small houses these are decidedly inferior to the "Star" or "Gem" boilers, especially as the thin metal casing soon burns through. Coils ought always to be set in brickwork.

A new and distinct form of independent boiler, known as the "Twelve Hours' Syndicate," has recently been introduced, and deserves mention. One of these boilers is shown in Fig. 136, and will be seen to consist of a kind of double circular furnace, with a water-way all round both, at the base, and a hopper, or top-feeder, placed on the first and larger one, the smoke-pipe being fixed on the second or smaller cylinder. The fire is contained in the first or larger part, and there is a grating between the two through which the draught passes into the back chamber, and thence up the smoke-pipe. The draught is regulated by means of the (sliding) fire, and ash-pit doors in front, and also by means of a small damper, or door, placed on one side of the back chamber, which, when opened wide, admits a quantity of cold air to the base of the smoke-pipe, and thus reduces the draught and consequently the amount of heat generated also, while when closed the draught is rendered stronger and more heat is obtained. The makers claim for this form

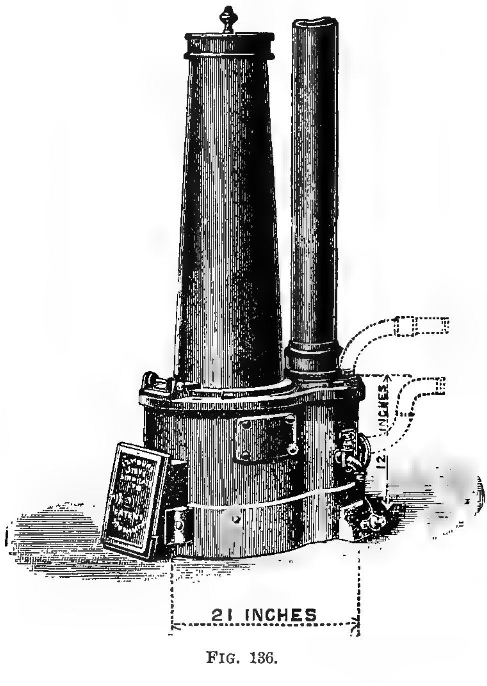


FIG. 136.

of boiler that the fire will keep alight from twelve to twenty hours without attention, and that a maximum of heat is obtained with a minimum consumption of fuel, while the temperature can be regulated with ease and great precision.

Having lately had some experience with two of these boilers I can recommend them, and the smaller sizes in particular, as fulfilling what is claimed for them admirably.

The "Loughborough" boilers (Fig. 137), which are of a horse-shoe shape, and are constructed to be built into the end or front wall of a small greenhouse, were much in vogue at one time, and a good many thousands are in use. They

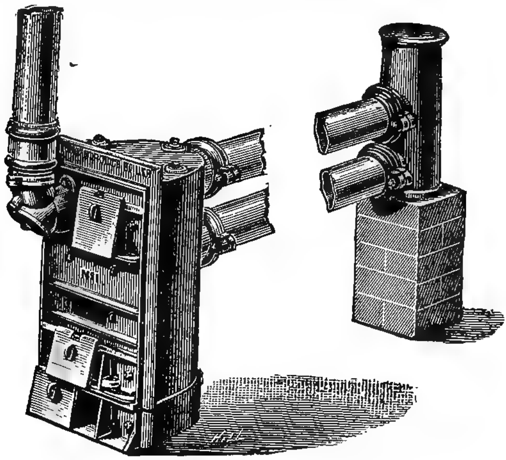


FIG. 137.

certainly possess some undoubted advantages, one of which is that a considerable proportion of the heat radiated by the boiler itself is not wasted outside, but is utilized inside the house, while they also have a very neat appearance, and for small structures are undoubtedly an improvement on the older forms. Their success of course induced a host of imitations, among which may be mentionted he

"Horse-shoe," the "Finsbury," the "Halifax," etc., of which the two last are, to my mind, among the best of their class.

A few other types of hot-water boilers, including the old "Elliptic," the "Delta" (a modification of the "Reliance" boiler), etc., still remain unnoticed, but these are so seldom required or employed that it is hardly necessary to refer to them. Those already described are amply sufficient for any and every purpose.

I heated my first greenhouse—a small lean-to affair only about 14ft. by 6ft.—with a couple of 9ft. lengths of 4in. cast piping (bought cheaply at second-hand), the furnace being placed in an adjoining cellar. The boiler consisted of one of those large cast-iron kettle affairs that one still sees occasionally in country houses where open grates are employed for cooking, and which are, or were, known by the name of "fountains." I screwed the lid of this down tightly, with some red lead, etc., drilling a hole in the centre and screwing in a ¾in. elbow for a connection with the flow, while the long spout, with the tap unscrewed, formed the return connection. I set it as well as I could, placing a chimney formed of a length of 5in. cast pipe, just outside, and the whole worked admirably, and though the total cost was less than £1, it heated the little house capitally for several years.

It is, indeed, quite surprising what can be done in this way with a few odds and ends of piping, a little contrivance, and Portland cement. I do not, of course, mean to convey that such ***makeshift*** apparatus are better than, or even quite equal to, a properly constructed affair, but these last are apt to run expensive, and beyond the means of a working man, or one whose means are limited, but a few shillings can often be spared where even the same number of sovereigns would be out of the question. To all owners of small green- or plant-houses of any kind who desire to heat them efficiently and yet find the cost of a proper ready-made apparatus, whether consuming coke, gas, or oil, beyond their means, I can strongly recommend the double-flue described on p. 205, and even if anything beyond this is required, it is easy to add a row or two of H. W. piping and heat it from the same fire, as there shown. A coil boiler (already described and illustrated), in connection with a few yards of piping of some kind, will, if properly arranged, afford even more satisfactory results, at a much lower cost than the ordinary run of hot-water apparatus, and something of this kind, in connection with a flue, will usually afford the highest possible degree of efficiency, combined with a very small consumption of fuel.

Hot-Water Apparatus to Consume Gas or Oil.—The more or less varied forms of these are now somewhat numerous, but really useful and effective makes, with a reasonably low consumption of fuel in comparison with the work done, are few. The construction of the boiler is the most important point, the arrangement of the piping being a comparatively simple matter. As previously stated, all the apparatus included in this section are only suitable for houses of comparatively small size, almost any type of boiler burning coke or coal (anthracite) being decidedly more economical where lengths of piping of over about 100ft. have to be heated.

The old conical-shaped boiler for gas, shown in Fig. 138, and usually made in either copper or tin, is so ruinously extravagant in fuel as to be totally out of the question, fully three-fourths, if not a still larger proportion, of the heat generated by the (atmospheric) gas burner passing directly away by the flue-pipe and being wasted. Some of the newer forms extensively advertised are but little better than the above, but others again afford vastly better results, and consume but little gas or oil in proportion to the work done. Some of the tubular forms are very good, those fitted with a number of horizontal tubes being much more economical than such as have vertical tubes only, though these are immensely superior to the old conical boiler. These tubular boilers on a small scale are however somewhat costly, and require frequent cleaning also.

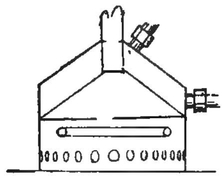


FIG. 138.

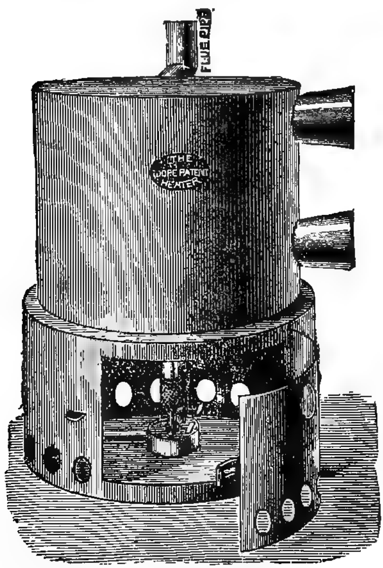


FIG. 139.

On the whole, decidedly the most simple and at the same time generally effective apparatus of this kind

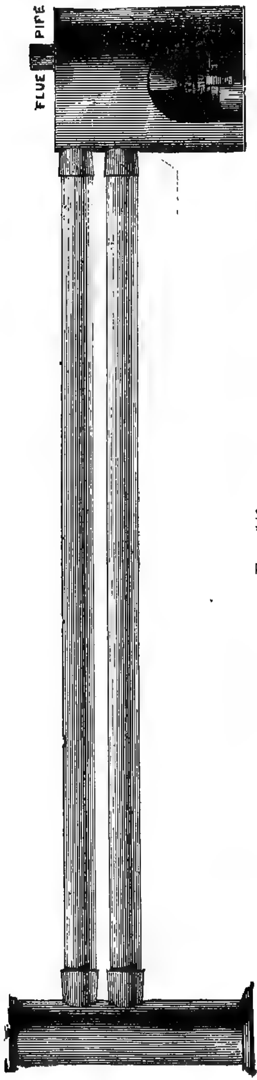


FIG. 140.

are those made by Messrs. C. Toope and Sons, of Stepney. The (patent) system on which all their heating apparatus are constructed will be understood at once by a glance at the accompanying illustration (Fig. 139) of their "Champion" heater. These heaters are constructed in various styles and sizes, but in spite of the simplicity of construction of the boilers they absorb the heat from the burner so completely that as a rule the flue-pipe is considerably cooler, at a few feet from the boiler, than the hot-water pipes. Fig. 140 shows Toope's "Princess" Heater, which from experience I can strongly recommend.

The "Radiator" oil-stoves have already been described and illustrated on pp. 149-150.

Flues.—The ordinary smoke-flue, which formed the chief dependence for heating glass structures of all kinds previous to the introduction of heating by hot water, consists of a furnace constructed as shown in Fig. 141, built into the wall of the house at some convenient point—usually at one end—and fed from outside. The body of the furnace, which of course projects inside the house, and should be placed so low down as to only rest *on* the ground level, or be partially sunk *in* the floor, must be substantially constructed of fire-brick and tiles, put together with fire-clay rather than mortar. From it the flue is taken, usually along the front of the house, to a chimney built just outside at the farther end. The usual size (internally) of a brick flue is 9in. by 9in., and it is generally constructed by laying *three* courses of a single brick on the flat (4½in. work), or *two* courses of a brick on edge, which of course comes to the same thing, for each wall, or side. Between these a space of 9in. is left, and the whole, when finished, is covered in with the flat square tiles, 1½in. or 2in. in thickness, known as "quarries." These are made in both red and blue material (the former being the most suitable for this purpose), and are 6in., 9in., and 12in. square, the last size covering a 9in. flue nicely, with 1½in. lap on each side.

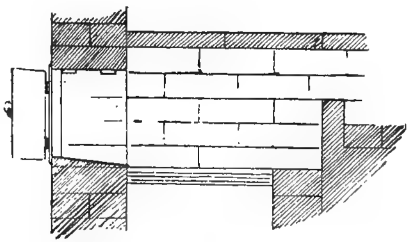


FIG. 141.

The tiles must be very well and carefully bedded in and jointed with the best mortar, and indeed the whole of the work must be made as sound and tight as possible. Fire-tiles ought to be used over the fire, and for a few feet from it, especially where the furnace is large, and it is a very usual and good plan to make a hotbed of sand over the furnace, for propagating purposes. Tiles about 1½in. thick, set on edge, are sometimes employed in building flues, but these make a very flimsy job, to my mind, and bricks (good kiln or pressed bricks are best), which if they do not transmit the heat quite so quickly, retain it longer when once heated, are decidedly preferable.

A bottom, or bed, of flat bricks or tiles must be put down first, of course, and should be about 18in. wide. If a gentle upward incline or slope, *from* the furnace, can be afforded, the fire will draw all the better; a rise of about 1in. per yard will do nicely. In some cases the base of the flue, formed of flat tiles, is raised off the ground, or floor, by means of bricks or tiles set on edge beneath every joint, but this is really not necessary, and a flue laid on a solid bottom answers perfectly well, while being much more substantial.

Flues consisting of ordinary (glazed) earthenware or sanitary pipes, with sockets, carefully jointed with a mixture of mortar and Portland cement, are not infrequently employed, and possess the advantages of being at once inexpensive, easily fixed, neat, and effective. The usual sizes of pipes employed are the 6in., 9in., and 12in., the first being most suitable for all ordinary purposes. Pipes only 4in. in diameter are sometimes used for quite small structures, but these are not to be recommended, as not affording sufficient sectional area to provide a good draught for even a small fire, and requiring to be very frequently cleaned also.

Note, that wherever these earthenware pipes are employed, the first 5ft. or 6ft. from the furnace must be built of brick, as the pipes are apt to crack badly under anything like a strong heat. In the case of a single flue, a good sized soot-door should always be built into the base of the chimney, both to enable it to be cleaned when necessary, and also to allow of an armful of shavings or straw being burnt, in order to create a draught when the flue is damp and cold, or the wind contrary. The worst of these single flues is that if the

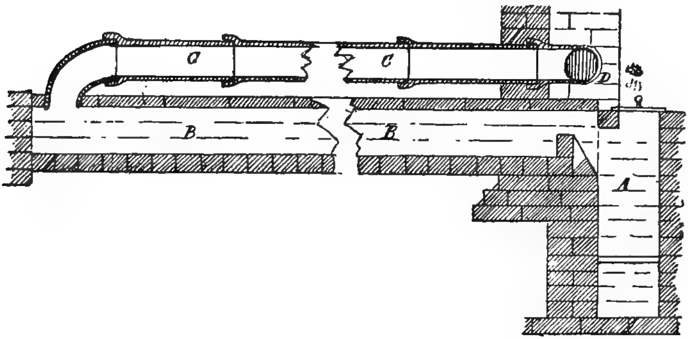


FIG. 142.

chimney grows cold, or the wind is wrong, it may stop drawing, and then the fumes, which are very destructive, are discharged into the interior of the structure.

The double flue previously recommended, and which is illustrated in Fig. 142, is immensely superior to all others in that the chimney is easily warmed at any time, or the fire in the furnace drawn up bright in a few minutes, by simply pulling out a damper, while the chimney itself, being built close to the furnace, is far more likely to retain its warmth, and the flue, consequently, to keep on drawing, than where the stack is at a distance from the fire.

In this excellent form of flue, of which the furnace is illustrated in Fig. 143, the lower, or "flow" portion (B B) is best constructed entirely of brick, as shown, though if more convenient the farther part, beyond the first 5ft. or 6ft., may consist of 6in. or 9in. pipes, as above. For the upper, or "return" portion (C C) the glazed socket-pipes already mentioned will answer admirably, and these may be fixed either directly over the lower brick flue (though this plan is rather inconvenient when the latter has to be cleaned), or be carried along at the side, though of course at a slightly higher level. Both flues ought to be constructed with a gentle upward inclination throughout.

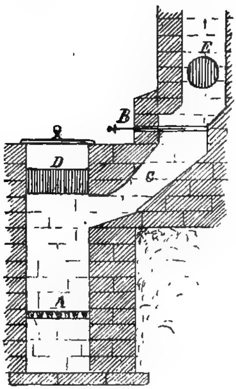


FIG. 143.

As already stated, the chimney is to be placed as near as possible to the furnace, and of course the farther end of the return flue discharges into it at E. Another and separate passage, or flue, C, leading directly from the back, or upper part, of the furnace into the base of chimney must be arranged, and be fitted with an ordinary damper, as shown at B in the illustration. When the fire is first lit this damper is pulled out, and the fire then draws directly up the shaft, but as soon as there is a good fire, and the chimney is thoroughly warmed, the damper is pushed in, when the draught is forced to travel round through the flue, which soon becomes warm. Should the fire become low or dull, or the draught become sluggish, pull the damper out for a few minutes, and all will go well.

The chimney, in all cases, should be of sufficient height to create a fairly brisk draught; the higher the shaft the stronger the draught will be, naturally. The usual rule in fixing steam boilers, etc., is to take the total length of all horizontal flues, etc., from the fire to the base of chimney, when about two-thirds of this distance will be the proper height for the chimney, and will afford a good draught. Anthracite or "hard" coal of any kind requires a stronger draught, however, than coke. For a flue, a chimney whose height equals half the total length of the flue, or rather more, usually answers well, especially if there is a good rise in the flue itself throughout.

Instead of the ordinary horizontal or "copper" furnace usually employed for flues, I have frequently used one of a deep, square type, as shown in Fig. 143. These are fed from the top, instead of in front, and when charged with fuel and the draught almost stopped by means of a tight-fitting door in front of the ashpit, the fire remains alight a good many hours, and affords a very steady and gentle heat. As the furnace has to be built entirely *outside* the house there may be a slight loss of heat at this point, but this is counterbalanced by other advantages.

In constructing a flue of any kind the following points, beyond the use of good materials and sound work, must be carefully observed:—(1) the avoidance of any damper or other obstruction in the base of the chimney, which would of course tend to throw the smoke, etc., into the house—this part of the flue should be perfectly free and roomy; (2) to "choke" the draught, if anywhere, just above or beyond the fire, where it enters the flue (in the case of the usual horizontal furnace a "bridge" should be put in at this point); (3) to stop the draught, when necessary, chiefly *below* the fire, by means of an ashpit door, with draught regulator; and (4) to provide proper soot-doors, or loose bricks, at all the necessary points for cleaning the flue easily, these being principally at the base of chimney, at the farther end of a double flue, and again opposite the end of the "return" flue, in the chimney, and also at all corners or elbows.

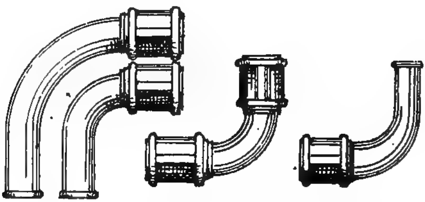


FIG. 144.

A flue may be employed in conjunction with a coil, conical, or indeed almost any type of boiler, care being taken, of course, that the total length of flues to be traversed by the draught is not too great for the height of the chimney, or the draught will be very sluggish. I have frequently employed a single or double flue to afford bottom heat, and obtained the necessary air-warmth from a small boiler and pipes. In some small houses, where very little heat beyond that provided by a flue is necessary, a few feet of piping may be heated without a proper boiler at all, by merely carrying a single, double, or treble row of pipes from 1½in. to 4in. diameter through the crown of the furnace, over the fire, properly connected to the usual circuit. This also I have accomplished in more than one instance with good results.

Hot Water Fittings.—Connections and fittings for joining and fixing the ordinary straight lengths of piping,

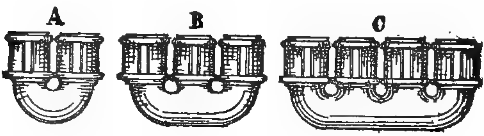


FIG. 145.

in almost every imaginable manner, are made by iron-founders, and may be obtained of any hot-water engineer or good ironmonger. Those chiefly required are the common elbow (Fig. 144), with either one or two sockets—long radius elbows, for use on outer rows where two rows are

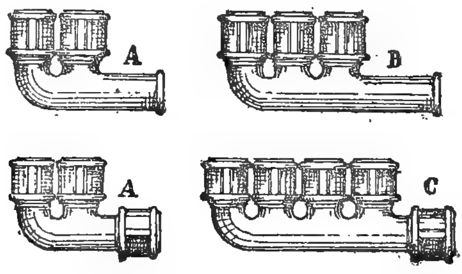


FIG. 146.

fixed side by side are occasionally, though very seldom, required—the syphon (Fig. 145), of which A is a plain syphon, B a three-way syphon, and C a four-way syphon. Plain *open* syphons are sometimes required.

Elbow syphons (Fig. 146) are employed where the ends of two or more rows of piping are to be connected and taken

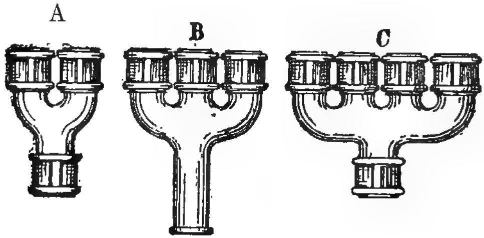


FIG. 147.

away at a right angle; A A are two forms of the ordinary elbow syphon, B a three-way, and C a four-way elbow

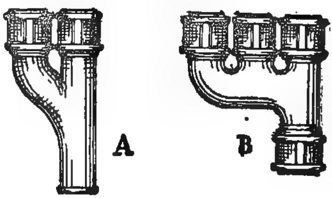


FIG. 148.

syphon. Another form of the same thing, but with straight outlets, is shown in Fig. 147; these are sometimes

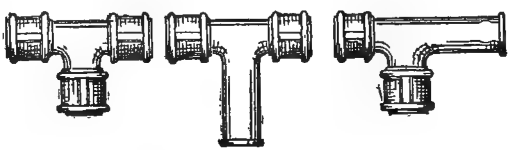


FIG. 149.

termed branch syphons. "Branch" pipes are shown in Fig. 148, where A is a two-way, and B is a three-way branch pipe or piece. T-pieces are shown in Fig. 149; these are cast in several forms, with one, two, or three sockets apiece, and they are also made with one or more reducing sockets, to suit different positions.

Cross-pieces (Fig. 150) are less frequently required, but

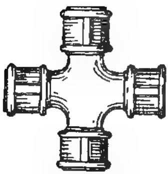


FIG. 150.

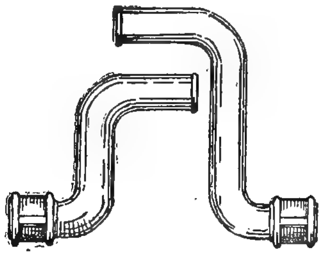


FIG. 151.

may also be obtained in the usual sizes. The swan-neck (Fig 151) is very useful for taking pipes from one level to a higher one, or *vice-versa*, and answers much the same purpose as two common elbows cast or joined together. These are usually made with set-offs of 9in., 12in., and 18in.

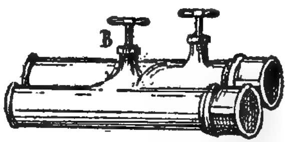


FIG. 152.

The H-piece is a useful contrivance for use where the current in two contiguous pipes (flow and return), is required to be occasionally stopped at a certain point, as at the end of one house, the pipes passing onward into the next (see Fig. 152). This fitting is frequently made with two throttle-valves, as shown, to prevent the current passing on any farther, but one, placed preferably on the *flow* pipe, is sufficient, and if a second one is employed it should be placed in the cross-pipe, as shown at B, in order to force the current to pass round the longer way when required.

Valves of several kinds are employed in hot-water fitting. The simplest and least expensive form is the ordinary throttle-valve (Fig. 153), which consists of a metal disc fitting the bore of the pipe exactly, and turning on a spindle passing through a stuffing-box at the top with a cross-handle outside. Being very simple in construction, and only roughly fitted, this form of valve is comparatively inexpensive, and though not by any means "tight" it is quite sufficient to check the current of hot water which, in most

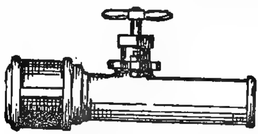


FIG. 153.

cases, is all that is required. An "improved" throttle-valve is now made, in which the disc and spindle are removable for repairs, etc., without disturbing the pipes at all; this is also more carefully fitted than the ordinary throttle-valve.

Where a really "tight" valve is required, either a "screw-down" or a "sluice" valve must be employed. In the former there is a circular opening in a diaphragm dividing the interior of a bulb-like enlargement on the short length of piping which forms the foundation of the valve. This opening is bored quite true, and is closed by a circular brass or gun-metal disc, turned to fit the opening exactly, and fitted on a spindle with a screw, stuffing-box, and a small wheel outside, as shown in Fig. 154. When screwed down these valves are both water and steam tight. The

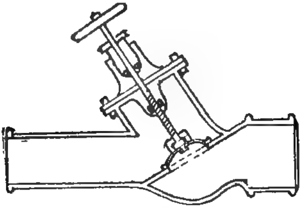


FIG. 154.

"sluice" valves (Fig. 155) consist of a sliding disc, or sluice, actuated by a spindle, screw, and wheel, as before, butwhen screwed down fitting tightly against a planed face fitted in the casting (see Fig. 156). When properly made these are even superior to the screw-

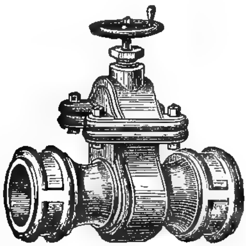


FIG. 155.

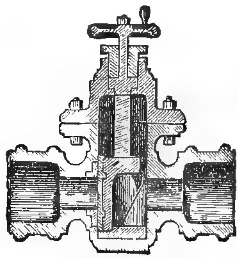


FIG. 156.

down or disc valves, the area of the opening being fully equal to that of the interior of the piping, and the passage also *direct*, without any diversion or obstruction of the current whatever. One of these forms must be employed wherever an absolutely tight stoppage has to be made, as in disconnecting one boiler from another one, or from the pipes, for the purpose of repairs, or wherever the water has to be kept back as well as the current checked.

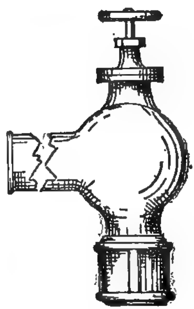


FIG. 157.

Screw-down "angle-valves" (Fig. 157) are frequently employed in connecting a set of heating pipes on to a main running on a lower level, and for such positions are very suitable, as well as being slightly less costly than the ordinary "straight" valves.

Coils.—It should perhaps have been mentioned previously that a "coil" of heating pipes is really a congregation of parallel pipes arranged either horizontally or vertically, for affording a large amount of heating surface

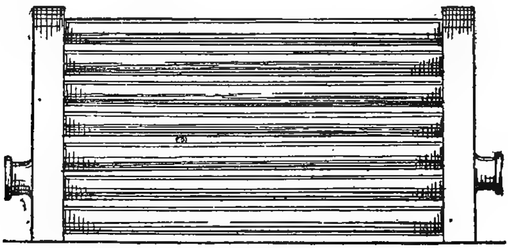


FIG. 158.

in a small space. Hence they are more suitable for heating churches, schools, and similar buildings than horticultural structures. Coils are made with from three to thirty or more lengths of piping, these being usually arranged in a single or double row (vertical), or in the case of a vertical coil in a circular or square form. The ends of the pipes are fixed and carried in suitable cast iron ends, with a hollow water-way, one of which is connected with the flow from the boiler, and the other with the return.

A horizontal coil is shown in Fig. 158, and a vertical (circular) one in Fig. 159. Ornamental covers of perforated or open-work iron are frequently employed to hide the unsightly pipes, etc.

Stoke-Holes.—As it has been already shown that in order to work well all boilers should be set well down below the level of the pipes, it follows that they must generally be sunk in the ground to some extent, and the larger the boiler the deeper must the stoke-hole be. Several forms of boilers that require a comparatively shallow hole have already been described (see pp. 187 and 189), and one or other of these ought to be adopted wherever any difficulty is experienced, or anticipated, in getting a sufficiently deep stoke-hole for the usual types. The obstacle chiefly met with in such work is water, and if this is found at a less depth than that necessary to get the boiler in properly the construction of the stoke-hole will be unavoidably rendered more troublesome and expensive—that is, unless it can be easily drained into some neighbouring deep sewer or outfall, when the difficulty of course disappears.

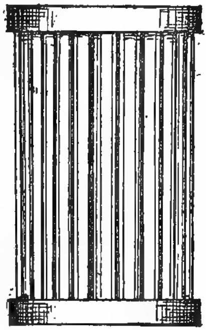


FIG. 159.

But where water is met with inconveniently near the surface, and cannot be got rid of, it must be kept out by some means, and in fact a kind of water-tight tank be constructed, but to keep the water *out* instead of in—a decidedly more difficult task, though by no means an impossible one.

One way out of the difficulty is, after having taken out a hole of the proper size and depth (the water being kept down by pumping, in the meantime), to sink, bodily, a galvanized iron tank sufficiently large to contain the boiler, or boilers, and allow room for stoking. This (which need not, of course, be much deeper than the extreme height to which the water is likely to rise), must be weighted down in some way, if there is much water, but by the time the boiler and brickwork are in place it will be steady enough, and where the upper edge is below the surface the sides should be carried up with good brick and cement work to the ground level, or rather above. Such a tank should, if possible, have a concrete bed to rest on, and also be filled in all round the sides with nearly or quite a foot of concrete.

But although appearing sufficiently feasible and even easy on paper, there are some serious objections to this method of excluding the water. In the first place tanks of such a large size are rather costly, running into £40 or £50 apiece if of only moderately large dimensions. Then, when down, the bottom frequently "buckles" badly, and I have seen cases where though level enough when first fixed, by the time the boilers and setting were got in, the brickwork and furnace fittings were terribly out of square through the bottom having given way to some extent. Lastly, a very few years' wear, with heavy nailed boots, coke, ashes, etc., suffices to wear holes through the bottom where the stoker stands, besides which rust and decay are never idle, and in fact the metal soon gives way and lets in the water once more.

Now a good brick and cement hole may be somewhat more troublesome and possibly expensive in the first place, but once well constructed it will last for a life-time, if not for ever, while any wear, etc., is easily made good at any time, if not allowed to go too far and let the water in again. The difficulty chiefly experienced in such a work as this is keeping the brickwork and cement dry until the latter sets firmly, and this can only be accomplished by constant pumping (by hand, steam or wind power) from a sump-hole sunk just outside the stoke-hole itself, and a little deeper, so as to drain the latter thoroughly.

The best way to go to work is to build the side walls first, using the best and perfectly sound kiln or pressed bricks, all wetted before use, and fresh Portland or hydraulic cement mortar. Now put down a good bed of concrete in the bottom, first, with a small drain of ordinary 2in. land-drain pipes, laid loosely, all round against the walls, discharging into the sump-hole, on each side. This keeps the floor perfectly dry, and when fairly set it may be covered with a course of heavy bricks on edge, well laid and grouted in with cement, and secondly with another course laid on the flat, also well bedded and grouted in. Now give the whole, walls and bottom, a good coat of cement and sand, put on very carefully, and keep on pumping until the whole is set quite hard. This will keep out any amount of water and prove almost everlasting. I have put down such a hole in a place where something like an underground river ran in a seam of gravel, and I quite thought I should have had to use an engine and centifrugal pump to keep the water down, yet it did not leak a drop, and has now stood for years. Remember that it is useless to try to stop an inward running leak with cement or anything else, as this cannot set. The water *must* be kept back until the cement is set, and then it will stand, if strong enough. If at any time the cement facing should wear or break away to the brickwork, put on a fresh coat at once, and don't touch it till set quite hard again.

It is far cheaper in the end to construct a good sound and tight stoke-hole at first than to have to keep on constantly pumping afterwards, not to mention the risk of the water rising badly some possibly frosty night and putting out the fire, probably with disastrous consequences.

Notes on Fuel and Stoking.—Ordinary gas-coke, broken up more or less small, according to the size of the furnace, is usually employed as fuel for most descriptions of greenhouse boilers and furnaces, and being at once inexpensive and almost entirely smokeless, it is on the whole very suitable for the purpose. Common coal, though affording considerably more heat, is quite inadmissible, owing to the amount of smoke and soot it produces, which, apart from the nuisance, would render the flues, etc., constantly foul. Good coke, free from clinker, and broken up small—in pieces about the size of hen's eggs—forms the best of all fuels for all the small independent slow-combustion stoves (boilers) described on pp. 196-8, coal of any kind being useless for these. In large furnaces the coke may be fed in large lumps, or rough, as it comes from the gas-works, or nearly so. Specially prepared, or oven-coke would be a decidedly superior fuel to gas-coke, as affording more heat, but its cost renders this out of the question.

Of late years the anthracite or Welsh smokeless coal has been employed as fuel for horticultural purposes to a considerable extent, and its use is steadily, if not very rapidly extending. Its advantages are that it gives a much stronger, as well as a very steady heat, lasting for many hours with little or no attention, and where it can be obtained at a moderate price—say anything under £1 per ton, delivered—it forms an on the whole cheaper and better fuel than coke—unless where this can be had very cheaply, say for anything less than 9s. or 10s. per chaldron of 36 bushels. This (anthracite) coal, in fact, must not be poked about much, or when hot it falls into small pieces, drops through the bars, and is wasted. A few fair to good-sized lumps thrown on a small but bright fire, and *left alone*, will burn steadily but surely out, and afford a strong and steady heat for several hours. It requires a rather sharper draught than coke, but this is easily afforded by slightly increasing the height of the chimney, and its use increases the heating power of a boiler by quite 20 or 30 per cent. over ordinary coke.

Some growers use a mixture of coke and anthracite, and this undoubtedly gives a very strong heat, but with the disadvantage of burning both the bars and boiler through much more rapidly than either fuel alone. An excellent plan, however, is to use coke during the day, when less heat is usually required, and anthracite for making up the fires at night. Where this is done, and the furnace is large enough to contain a sufficient supply of fuel, the thermometer inside the house will be found very little, if any, lower at 6 or 7 a.m. than when the fire was made up at say 10 p.m. the previous evening.

The main points to be observed in successful and economical stoking may be briefly summed up as follows:—Keep your fire-bars clean, and watch the weather. No fire can burn properly, or even if it does burn, cannot heat the pipes or houses well with the apertures between the bars choked with dust, clinkers, etc. Some men will keep the front part of the fire clean enough, but the back is allowed to become blocked up with dust and rubbish, consequently only half to two-thirds of the full or proper amount of heat is obtained. To clean the bars properly, the fire should be pushed back and the front half of the bars thoroughly freed from dust and clinkers ; then draw all the fire forward, rake out every bit of dust, etc., from the back, right up to the bridge, or end, then push part of the fire back again, spread it out evenly, throw on a *little* fresh fuel all over, let it draw up bright, and then bank up as required. In order to secure the maximum heat this operation should be gone through *twice* every day—morning and evening—and I have known more than one case where it made all the difference between plenty of heat in the houses and little or none.

The weather, as well as the direction of the wind, etc., must also be carefully watched, and the fire regulated accordingly. A strong fire when the sun is rising brightly after a cold night will usually do more harm than good, and is simply waste of fuel. In cold weather, always get a good fire and the houses warm towards evening, and bank up on a *nice, bright,* but rather low, fire, and hot pipes. Nearly all furnaces draw better with the wind some ways than others, so regulate the draught accordingly.

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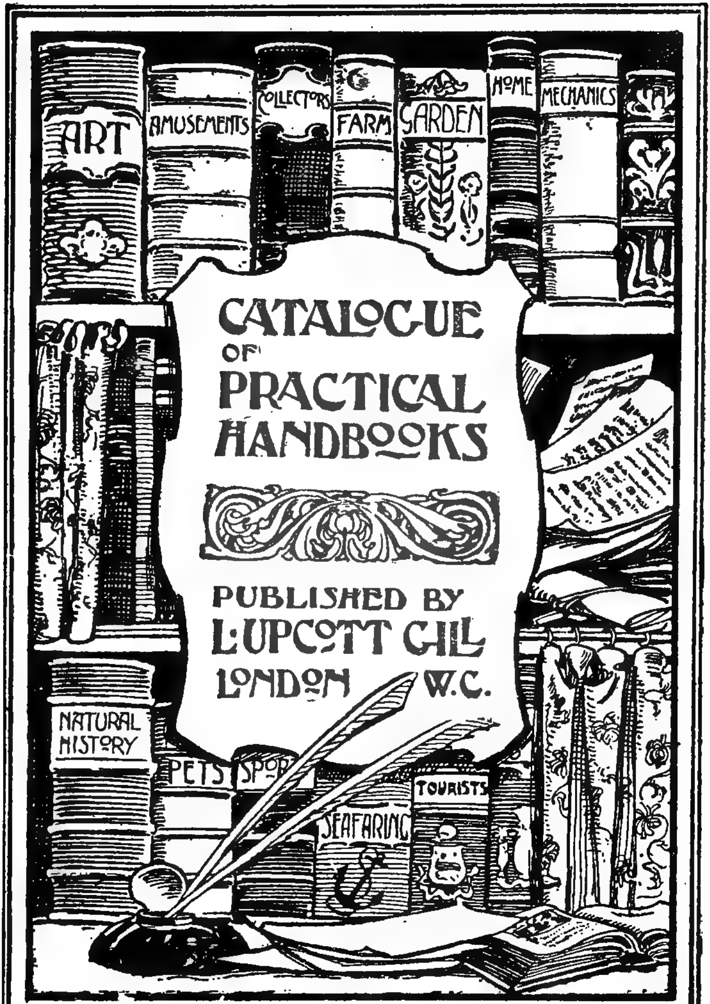

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